New Java SDK for handheld devices!

REVIEWED
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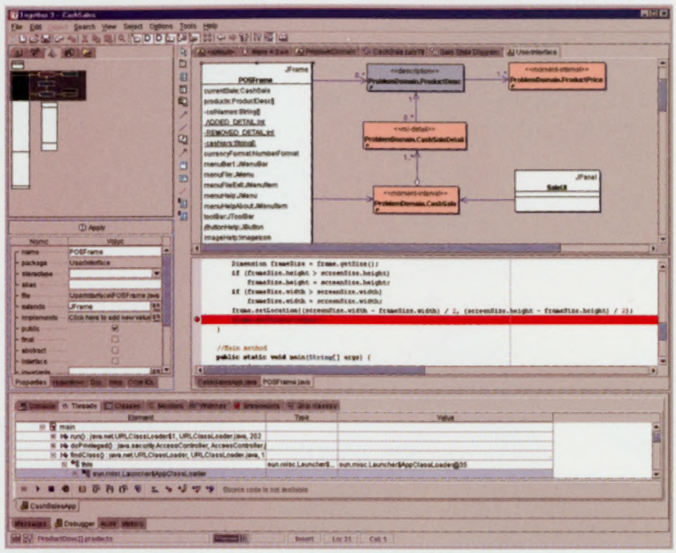
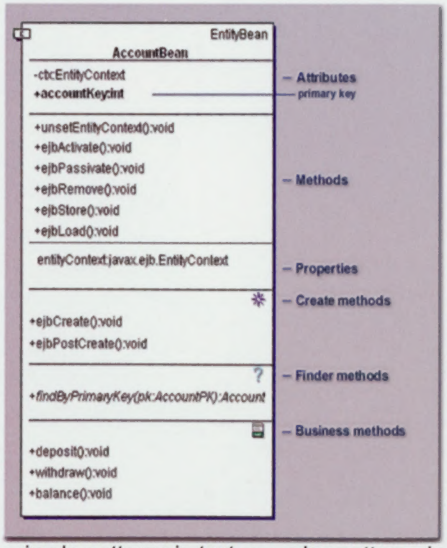
New! Together Control Center 4.0

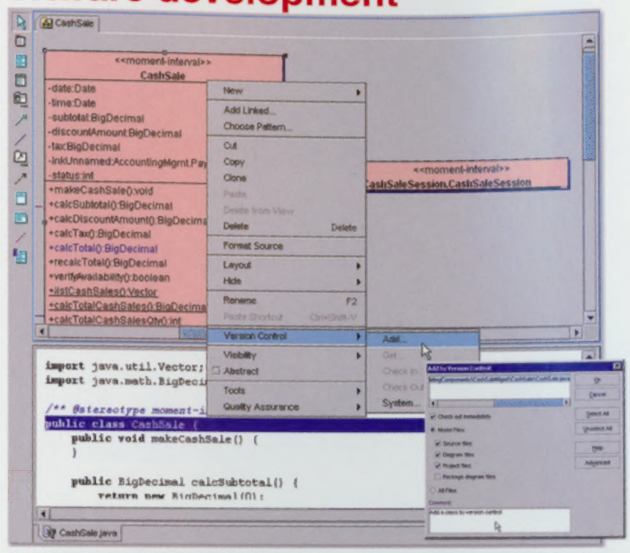
Model, pattern, edit, gen doc, version, doc, audit/metric, compile, debug, provision, assemble, deploy, run—what The Home Depot calls "the backbone of all our software development"



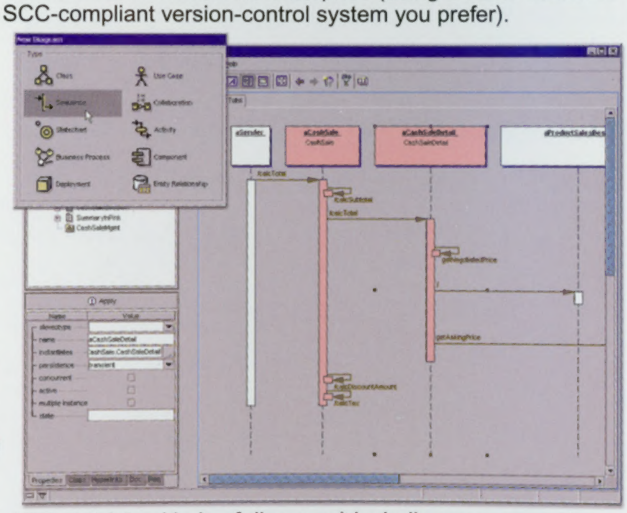
OneSource™ simultaneous round-trip engineering—class diagrams and source code, always-in-sync, always up-to-date, giving you complete freedom to work visually or textually (Java, C++, or IDL) as you see fit. Plus robust programming editor with syntax high-lighting and auto-completion features; compiler with messages auto-linked to diagram element, source-code line, and property editor; and distributed, multi-threaded debugger.



EJB features: generate, configure, reconfigure, customize, and compile. Visually edit your create, finder, and business methods in any EJB; Together auto-updates the supporting interfaces and primary-key classes (hidden from view, unless you choose otherwise). Plus round-trip EJB-JDBC, round-trip ERD-JDBC, and round-trip JSP-JavaBean support. Also generate, configure, reconfigure, and customize GoF patterns. Add your own company-specific patterns too (express simple patterns in text, complex patterns in Java).



BigPlay™ team support is just a mouse-click away—complete end-to-end multi-user version control for models, source, and documentation across the enterprise (using CVS or whatever SCC-compliant version-control system you prefer).



UML 1.3 (nine kinds of diagrams) including reverse engineering of any source code into sequence diagrams. ERDs too. Plus RaftMaker™ customizable multi-level doc (Javadoc 2 superset plus RTF)—invoke it as part of your daily build, deliver always-up-to-date doc to your boss.

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"I really like Together...No other vender has even come close to making such an intuitive and convenient diagramming interface."—David Marine, Sr. Web Applications, **NetSolve**

"We discovered in our evaluation that other modeling tools only get used during the front-end of a project. Yet we found Together to be the one UML modeler that our developers will use from start to finish. Why? It's the only one that delivers simultaneous (rather than batch-mode) round-trip engineering"—Curtis Chambers, **The Home Depot**

"Thanks for your wonderful product, I just did a download and install of Together Control Center 4.0. I wonder how you guys find time to incorporate so many additional new features in the short span of time between version 3.0 and 4.0. I am, as a power user of your product very happy to see your progress. Great and good job. Keep it up."—Suresh Balamaran, **TimeO, a Perot Systems Subsidiary**

"Together Enterprise is a team development management tool. It provides simultaneous round-trip engineering (for Java, EJBs, C++, and JDBC); multiuser team development; multilevel documentation generation; a pattern maker with modeling components; customizable metrics checking and likely-error audits; and a UML 1.3 custom diagram definer. It fully supports EJBs, traces requirements, supports large projects, and offers extensive customization options and integration with other products. Together supports IDL and DDL, and e-business plug-ins. Together Enterprise 3.2 also includes a new Project expert, improved "finest level of detail" Rose import and export-it no longer requires running Rose to import or export-plus additional metrics and audit features, including bar charts and and Keviat ("spider web") graphs."—**JavaPro Reader's Choice Award**

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"Having seen Together's direct use of Java code to support the models, I am forced to wonder why anyone would like to work in any other way! I do think that the strength of the product lies in its interoperability—it's a 'complete solution', not just a modeling tool."—Jon Collins, Senior Analyst, **Bloor Research**

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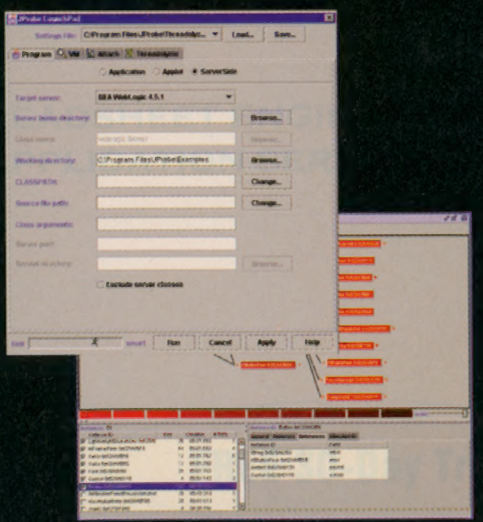

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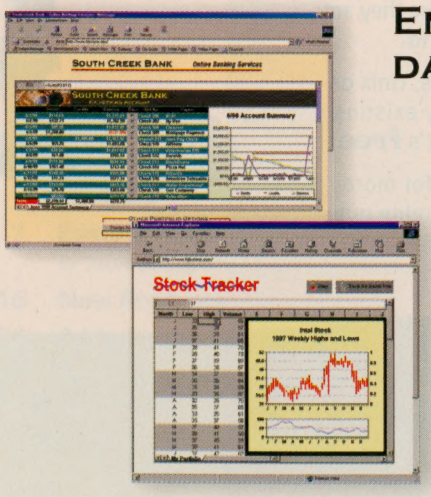

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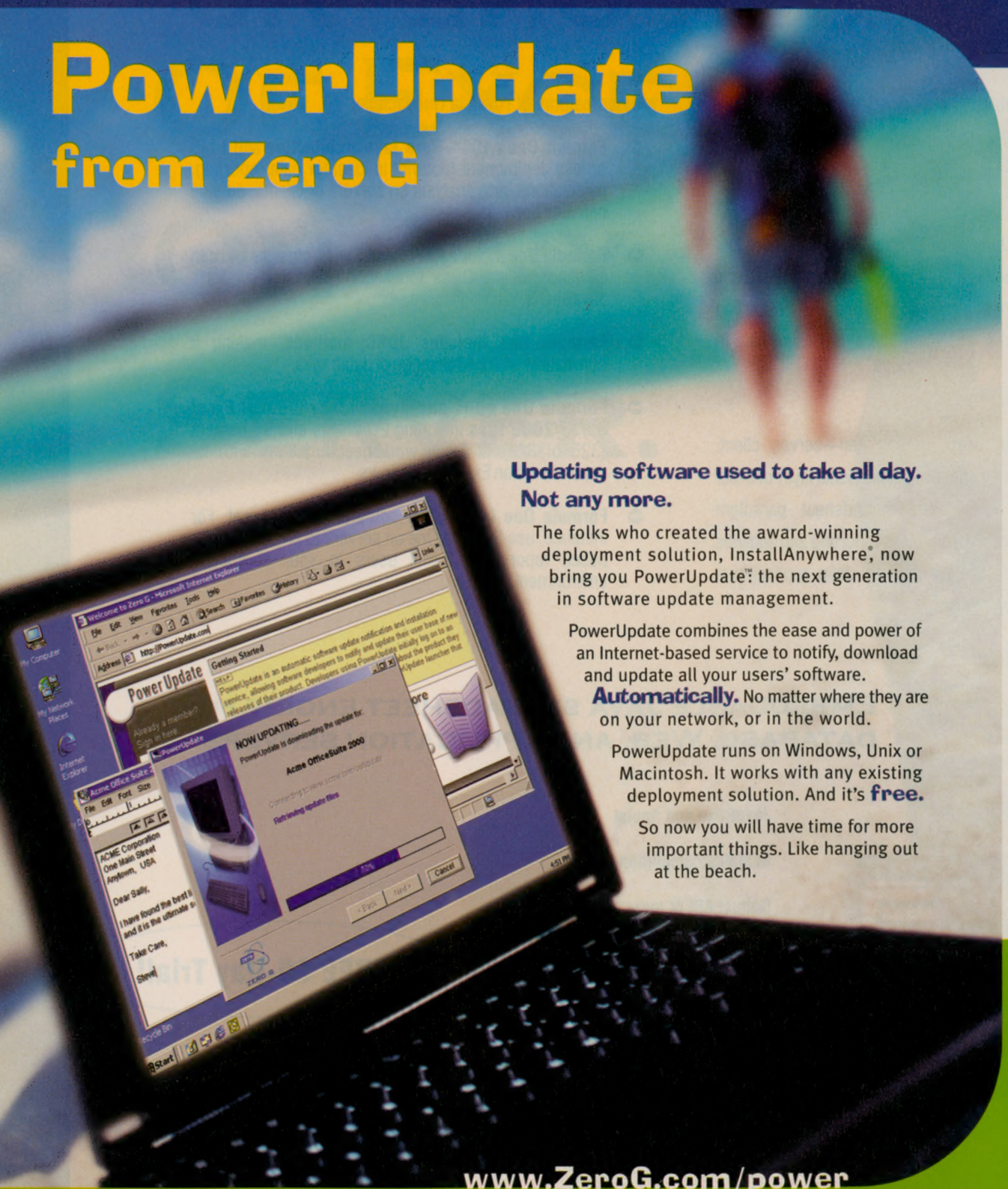

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Problem Solved

by Sean Gallagher
Editorial Director
sgallagher@fawcette.com

Now that I've put my tuxedo back in mothballs where it belongs, I can look back with some perspective at the exercise in self-abuse, hair-pulling, and teeth-gnashing that we called the Java Technology Achievement Awards. At JavaOne we and the fine folks at Sun Microsytems were privileged to recognize some people who've done a lot for the Java community—and some who've put Java technology to good use.

The Java Community Awards went to people who have made outstanding individual and team contributions, respectively, to the Java community and Java technology: Dr. David Megginson, who has been the driving force behind the Simple API for XML (SAX) for Java; and the Blackdown.org team, who collectively have worked to port the Java VM to Linux.

Both SAX and Blackdown's VM are examples of what's good about Java and the Java community. They demonstrate how open source and open standards benefit the developer community and drive software innovation—and they reflect the strength of the community that has grown around Java technology, despite whatever politics and marketing spin have clouded the issue.

A lot of the bad blood that has seemingly existed between Sun and the other members of the Java Community Process appears to be going away—or at least going into remission. Oracle recently licensed J2EE branding, and there's been some movement on Sun's part to open the Community Process up a bit. That's important to developers, because it means that the risk of Java technology becoming "unix-fied" by competing vendors creating different implementations of the language (anybody remember Xbase?) is in decline, and that developers can count on both their Java skills and their code being more portable from vendor to vendor and platform to platform.

While the winners of the Java Community Awards demonstrated the kind of talent working to extend the reach and functionality of the Java platform, the *Java Pro* Java Solutions Awards winners show how far Java has come as a business platform. We presented Solutions awards in seven categories:

- Best Java-driven Web Site: Flashline.com, for its online software component and tool sales site
- Best Java Enterprise Application: Charles Schwab, for its Java trading application infrastructure
- Best Use of Enterprise JavaBeans Technology: Project Achieve, for its educational support application service
- Best Java E-Commerce Application: Cisco Systems, for its record-breaking e-commerce site
- Best Java Mobile/Wireless Application: Home Depot, for its wireless store–floor sales system
- Best Java Client/Front End: Freeback.com, for a Java Web interface to a free Internet file backup and storage service
- Best Nonprofit/Social Action Use of Java: The National Center for Missing and Exploited Children, for its Java-based information infrastructure.

The Java Pro Java Solutions Awards winners show how far Java has come as a business platform

We'll feature case studies of some of these winners in future issues. But all the solutions that were nominated and reviewed reflected something we were fairly certain of before—how deeply Java has taken root in the enterprise. The hundred or so submissions we pored through to pick winners for these awards all demonstrated how flexible and effective Java can be when put in the right hands, and how critical a part of business developers' toolboxes Java technology has become. ■

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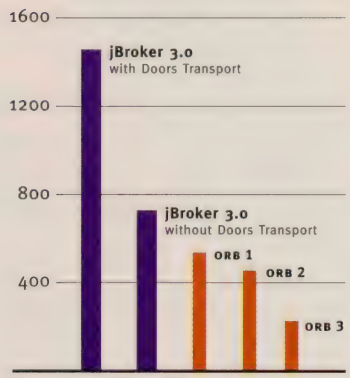

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Reviews

InstallAnywhere 3.0 Enterprise Edition

InstallAnywhere 3.0 Enterprise Edition

Software Deployment the Java Way

by Michiel de Bruijn

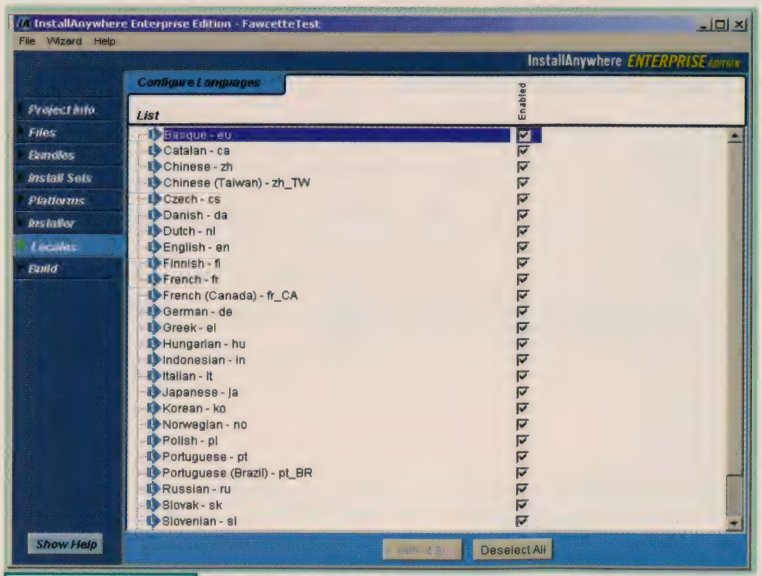
Quick Facts:

Although it lacks the polish of some of its competitors, InstallAnywhere's broad feature set, which includes native MacOS support, definitely makes it a product worth looking at.

Zero G Software, Inc.
514 Bryant Street
San Francisco, CA 94107
Phone: 707-924-0707
Web: www.zerog.com
Price: $1,995

Given the wide range of systems they have to run on, installation programs are a natural fit for Java's cross-platform capabilities, and indeed, more and more products in this class are appearing on the market. Zero G Software's InstallAnywhere is a relatively recent entry, and it packs a healthy set of basic installer features, as well as in-house deployment capabilities targeted at the enterprise market.

Using the InstallAnywhere GUI, which can be run in either a wizard-based or advanced mode, you can pretty much get everything you need done quickly and in a friendly way. Selecting files to be installed anywhere on the target system and creating install sets based on user selection (for example, minimal, full, and custom installations) or the platform your install app is running on is literally a matter of minutes.



Parlez-vous Java? Extensive multilingual support makes InstallAnywhere Enterprise a good choice for organizations with non-English target audiences.

Uninstall support is automatically added to each project you create, and in most cases, InstallAnywhere will be able to automatically determine the main class for your application.

Features like Java class path modification, password-protecting your installations, and requiring a serial number in a specific format are supported as well, although the arrangements of these features in the GUI may leave you searching for them at first.

Making a Bundle

Early Java-based installers always required a Java Virtual Machine (JVM) to be present on the target system before the setup program could run, which caused issues in some situations—especially those where completely unattended installations or novice users were involved.

InstallAnywhere, like most other recent install apps, takes the approach of bundling the JVM for the most popular target platforms along with the setup application. This ensures that the installation will at least succeed on Windows, Macintosh, and Solaris machines, regardless of whether they already have a recent JVM installed or not.

Speaking of platform-specific features, InstallAnywhere also gives you easy access to a number of those, such as the ability to modify the Windows Registry, create desktop shortcuts, and install to a special file location.

The icons you supply for your application are also kept in a generic format, and converted to the specific file type in use on the target platform at installation time.

Get It Just the Way You Want

In case its basic feature set is just not sufficient for you, InstallAnywhere allows extensive customization of the setup programs you create (see figure). You can add custom Java code actions to just about every step of the process, and adding extra user interface panels is easy as well.

You can also use InstallAnywhere's Application Programming Interface (API) for even greater control over what happens before, during, or after the setup process. At the time I wrote this review, just a few simple examples of actually using this API were available, but a new developer's program, which includes access to a special section of Zero G's Web site, is supposed to rectify that.

All in all, InstallAnywhere measures up quite well in the increasingly competitive field of cross-platform installation products. Whereas its closest competitor, InstallShield for Java, has better support for Solaris, the Zero G product is stronger in native Macintosh support (for instance, allowing you to preserve resource fork information and install control panels and extensions).

Other strong features include localization and easy Web-based distribution. The product's price and the fact that it stamps a "created by InstallAnywhere" banner on all your installation programs are less positive, but shouldn't really detract from an otherwise great product. So, if you're in the market for a Java-based installer, definitely download an evaluation copy from the Zero G Web site and take a serious look at it. ■

Michiel de Bruijn *lives in Rotterdam, The Netherlands, and spends his days as a networking and development specialist for an international media group. He seems to enjoy living on the bleeding edge of technology. Michiel always welcomes questions and comments: reach him at mdb@x42.net.*

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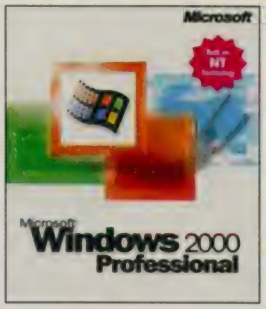

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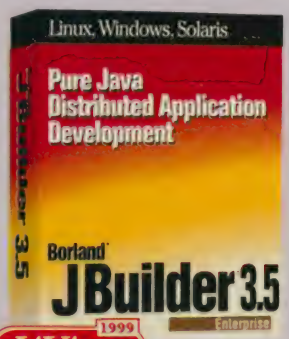

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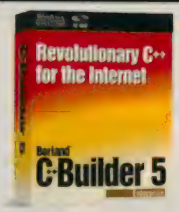

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Serving XML with JavaServer Pages

Today's e-commerce sites must interoperate with software components of all types, not just Web browsers

by Duan Yunjian and Willie Wheeler

Every successful e-commerce system has two major requirements: it should be usable and interoperable in a heterogeneous computing environment. In the case of usability, Web applications, such as e-commerce sites, can't look to desktop applications for a good model. It's sad but true; mediocre or even poor usability is sometimes tolerable for desktop applications since the money has already changed hands by the time the shortfall is discovered. In a Web application, however, mediocre usability is *not* an option. On the Web, the shortfall is discovered *before* the customer pays, and the competitor's Web site is always just a click away.

E-commerce systems must be able to work with other systems running on widely varying hardware and software platforms, including desktop machines with big or small monitors, PDAs, cell phones, and so forth. In any highly competitive business sector, no one can afford to turn customers or potential business partners away because their systems are "incompatible."

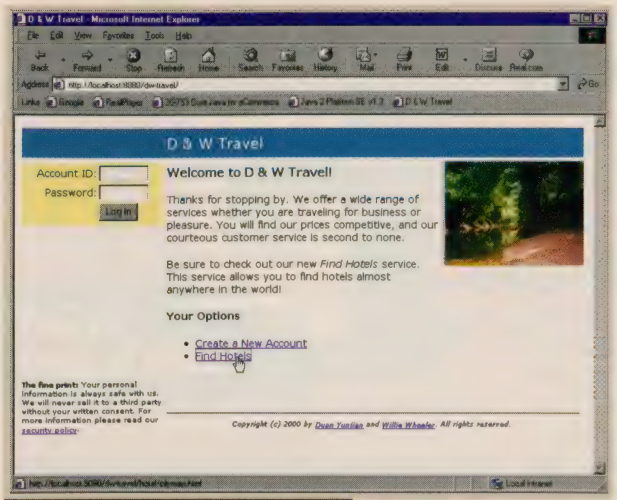
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Figure 1 Welcome to D&W Travel Users can choose the "Find Hotels" option to begin their travel planning. This will take the user to citymap.html, where they can interact with the city image map.

Besides the two quality attribute requirements of usability and interoperability, an e-commerce site must be able to deliver dynamic content because business data is inherently dynamic.

None of these requirements is trivial, and when combined, they can pose a real challenge. For example, the standard way of presenting dynamic content is to generate HTML on the server dynamically and then deliver it to the client, which is assumed to be a Web browser. This can work against usability, since HTML does not provide an especially rich set of controls with which to develop a user interface. It can also work against interoperability, since communicating with non-browser clients becomes problematic.

In this article, we will explore an approach to meeting the usability, interoperability, and dynamic content requirements that face any e-commerce development project. Our approach is to use JavaServer Pages (JSP) to serve XML. We illustrate the concepts by way of a simple Web site for an e-travel business. We will use JSP to generate dynamic content, and XML to help achieve usability and interoperability.

To run the code you will need to have a number of things, all of which are freely available. First, you will need a Web server with a JSP engine. We recommend Apache's Tomcat 3.1 (http://jakarta.apache.org/tomcat), which you can get for Windows, Solaris, and Linux. (If you use Tomcat, remember to set the JAVA_HOME environment variable to point to your JDK directory, and add an entry to the server.xml configuration file for our travel application, which is called dw-travel.) Second, you will need a Web browser that supports XSL Transformations (XSLT), which currently leaves you with one choice: Microsoft Internet Explorer 5 (www.microsoft.com/windows/ie). Netscape (even the Netscape 6 Preview Release 1) will not work. (This does not contradict our interoperability claims; you will have to keep reading.) Third, you will need the Java Plug-in (www.java.sun.com/products/plugin) since our application includes a Java 1.2-based applet. (Again we will see that this does not contradict our interoperability claims.) Fourth, the code requires Sun's Project X XML parser (www.java.sun.com/products/xml). (Any W3C-compliant DOM parser should work, but you will need to modify the code in CityDao.java a bit if you use a different parser.) Finally, you will need the code itself, available at www.java-pro.com.

In any highly competitive business sector, no one can afford to turn customers or potential business partners away because their systems are "incompatible"

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D&W Travel is a fictional e-travel service that aims to provide global travelers with a convenient way to plan their trips. A full-blown version of the site would allow global travelers to create an itinerary through a convenient graphical user interface. For the purposes of this article, it will be sufficient to develop functionality that allows the user to look for hotels. When the user first arrives at the site, she is greeted by a home page that allows her to log in, to create a new account, to find a hotel, or to look at the security policy

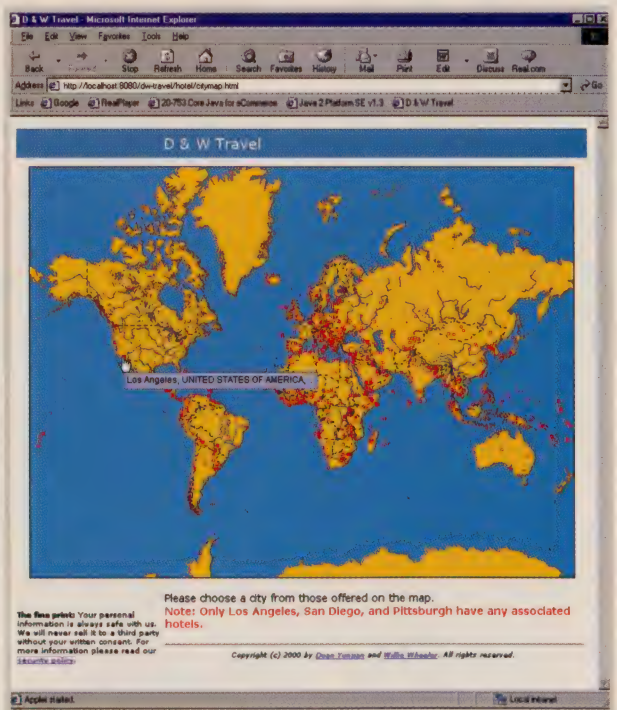
D & W Travel
Los Angeles, UNITED STATES OF AMERICA
Please choose a city from those offered on the map.
Note: Only Los Angeles, San Diego, and Pittsburgh have any associated hotels.

Figure 2 Choose a City The user is interacting with the applet. Moving the mouse over a city (a red dot) causes a tool tip to appear. If there are lots of cities near where the user clicks, a dialog pops up asking the user to choose exactly one of the cities.

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Willie is a master's student in human-computer interaction at Carnegie Mellon University. He is a research associate at the Laboratory for Symbolic and Educational Computing at CMU, where he is helping to develop Web-based courseware on causal and statistical reasoning. His interests include educational computing, as well as supporting HCI through sound software engineering. Willie has a bachelor's degree in mathematics and philosophy.

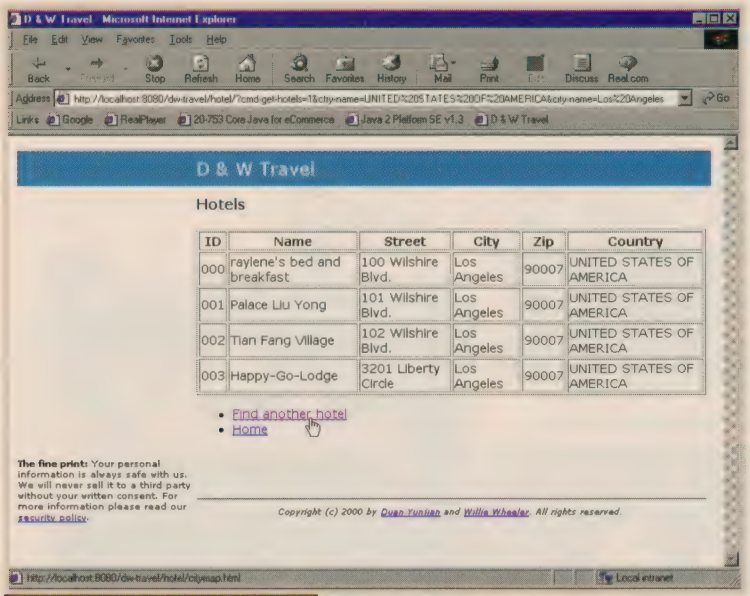
D & W Travel - Microsoft Internet Explorer
D & W Travel
Hotels
ID | Name | Street | City | Zip | Country
000 | raylene's bed and breakfast | 100 Wilshire Blvd. | Los Angeles | 90007 | UNITED STATES OF AMERICA
001 | Palace Liu Yong | 101 Wilshire Blvd. | Los Angeles | 90007 | UNITED STATES OF AMERICA
002 | Tian Fang Village | 102 Wilshire Blvd. | Los Angeles | 90007 | UNITED STATES OF AMERICA
003 | Happy-Go-Lodge | 3201 Liberty Circle | Los Angeles | 90007 | UNITED STATES OF AMERICA
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Figure 3 Here Are Your Hotels The hotel list for Los Angeles in HTML format. The HTML file is generated from the XML source and XSL stylesheet by client-side XSLT. If you view the source from IE5, you will see XML, not HTML.

(Figure 1). In fact only the "Find Hotels" functionality actually works in our toy implementation; the other options are there just for looks. Trying to log in just returns you to the home page as if nothing has happened, and clicking on "Create a New Account" or "Security Policy" tells you that you've followed a dummy link.

When the user selects "Find Hotels" from the site home page, she is taken to a new page from which she can choose a city on an image map (Figure 2). Different things happen depending on where she clicks. If she clicks somewhere where there is no city, nothing happens. If she clicks on exactly one city, then that city is selected. If she clicks on an area that contains multiple cities, then a dialog box appears and asks her to select exactly one city.

Once the user has selected a city, the Web app takes her to a third page, which displays a list of the hotels that are in that city (Figure 3). In our implementation, only three cities have any hotels at all: Los Angeles, San Diego, and Pittsburgh. If you click on one of these cities, then the hotels for that city will be listed. If you click on any other city, then an empty list will appear.

Application Architecture

The application uses a standard three-tiered architectural style (Figure 4). The tiers are logical, as opposed to physical, computing tiers. The first tier is the presentation tier, which presents application data to the user. The middle tier consists of business objects and application logic, and it provides a well-defined set of interfaces that the presentation tier can access to request business services. The third tier is the data tier, and it provides for business object persistence. Usually the data tier will be home to one or more relational databases, but for our purposes flat file persistence will be sufficient. The three-tiered model is more flexible and scalable than the traditional client/server architecture, which is why we use it.

The first tier of our application includes browsers, Java applets, and standalone applications (whether Java-based or not). For this article, however, we will focus upon the IE5 Web browser and the CityMapApplet image map for reasons that will be clear later. On the middle tier we have a Java-based Web application designed in the Model-View-Controller (MVC) style, as we describe in the next section. On the third tier we have a single flat file containing hotel data. (Our application also includes an XML file that contains city data, but we can consider this a Web document since it exists under the Web app's document root, and clients obtain it essentially by pointing to it directly.) The presentation tier sends messages to the middle tier by encoding commands and arguments in HTTP requests. The middle tier responds with XML, either statically generated (served from an XML file) or else dynamically generated (served by the JSP). Using XML instead of HTML, as we shall see, means that we can have dynamic content without sacrificing usability or interoperability.

See Figure 5 for a class diagram of the D&W Travel site.

Web Tier

The application produces two types of data for client consumption. The first sort of data is city data, which includes (among other things) a name and coordinate data. For us, city data is static in the sense that when a client requests city data, we don't need to figure out which records will be sent—we always send it all. In other words, we can put the city data in a file and point the client at the file. The second sort of data is hotel data, which includes a name, an address (in particular, a city), and phone numbers. Hotel data is dynamic since the list of ho-

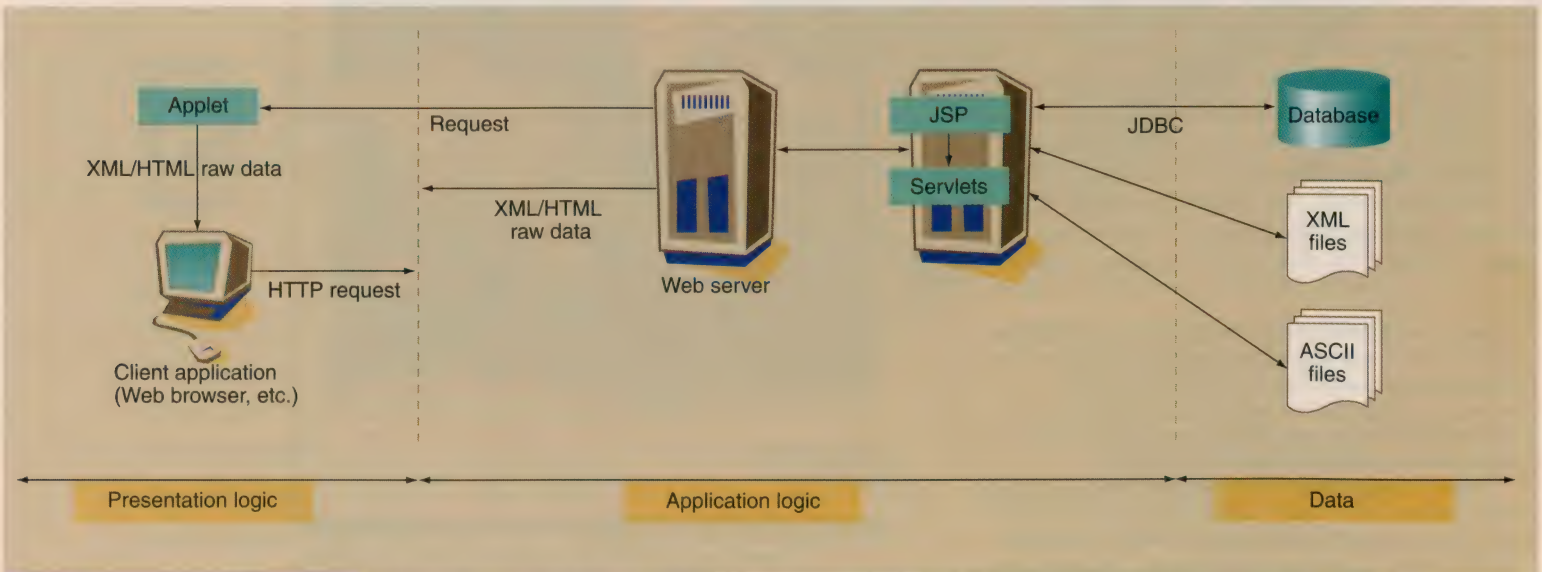

Figure 4 Three-Tiered Architecture Our application uses the typical three-tiered architecture. The first tier provides a way to present data to the user. The middle tier is in charge of retrieving the data from data sources and provides a well-defined interface for the first tier to access the data. The third tier contains the data sources.

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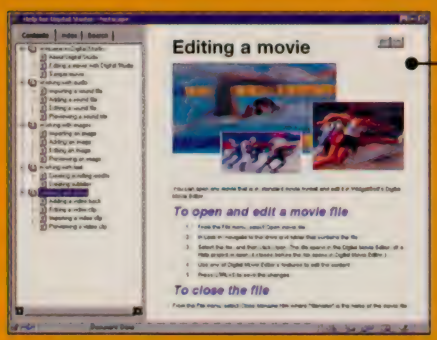

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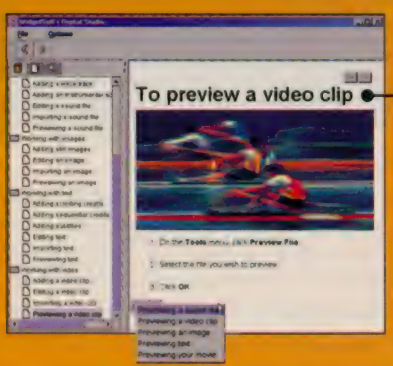

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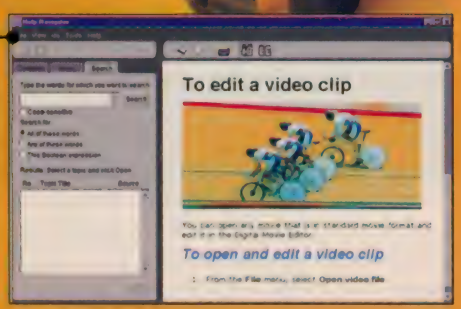

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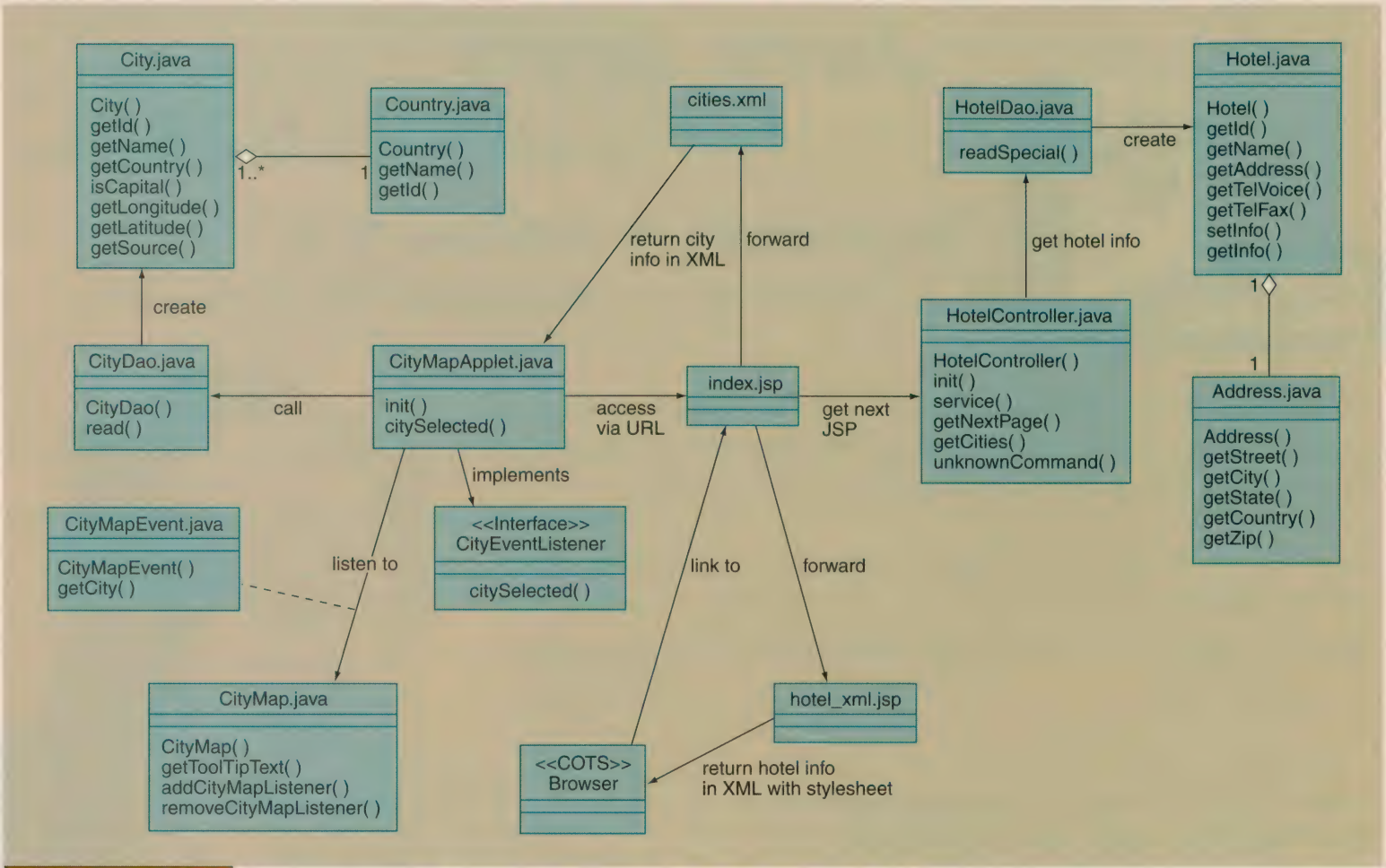

Figure 5 Class Diagram This figure illustrates the relationships between the classes and interfaces in the application.

tels returned to clients depends upon which city is specified. This means that we cannot use the same approach. Instead we need a server-side mechanism for reading the hotel data, deciding which data has been requested, and then sending it over the lines. (Actually we could define for each city a separate, static file containing the hotels in that city, but this would make it difficult to perform hotel queries using anything other than cities. So we will just treat the hotel data as dynamic.)

Now we will explain the server-side machinery necessary to service client requests for data. In the standard MVC-style Java-based Web application, JavaBeans connected to a back-end (maybe a database, maybe Enterprise JavaBeans) form the model, HTML pages and HTML-centric JSP pages are the view, and either a servlet or a JSP front component (usually in conjunction with a helper component) constitutes the controller. (For a more detailed treatment, see "Divide and Conquer Your Workflow with JSP" in the April 2000 issue of *Java Pro*.) As we pointed out at the beginning, this way of building a Web tier introduces certain problems for usability and interoperability. It means that clients have to be HTML clients, which is limiting from the perspectives of usability and interoperability. This would not work for us, since the D&W Travel site has an applet (no generic HTML-parsing capabilities) that needs to obtain city data from the Web app. Looking to the future, it is clear that serving HTML would not satisfy our interoperability requirements, since it would prevent interoperation with many of the new consumer electronic devices.

The solution is to serve the data as unformatted XML instead of serving it as formatted HTML. In the case where the data is static (such as our city data), we can serve XML files directly. If, on the other hand, the data is dynamic (as is true of our hotel data), we can use JSP pages to generate XML dynamically. This is exactly what D&W Travel does.

Let us examine the Web tier in more detail. All hotel-related client requests come in through the hotel/index.jsp front component:

```
<jsp:useBean id="ctrl" class=
  "dw_travel.hotel.HotelController"
  scope="session">
   <% ctrl.init(
    application, session); %>
</jsp:useBean>
<% ctrl.service(request); %>

<jsp:forward page=
  "<%= ctrl.getNextPage() %>"/>
```

The <jsp:useBean> element creates and initializes a session-scoped HotelController instance for the client, if one doesn't already exist. Then it uses the HotelController to process the client request. Finally, it asks the HotelController what the next Web page will be, and forwards the request to that page. We already said that the page contains XML content; whether the page is a static XML document or dynamically generated XML depends upon whether the requested content is static or dynamic.

As a brief aside, we chose the name index.jsp for our front component since Tomcat treats it as a welcome file. This means that Tomcat maps the URL path /dw-travel/hotel/ to /dw-travel/hotel/index.jsp in the absence of competing welcome files. Thus /dw-travel/hotel/ is an entrance to the hotel module. If you are not using Tomcat, then your servlet engine may or may not treat index.jsp as a welcome file. In this case, you can fix things (for the purposes of our app, anyway) by using the following in the WEB-INF/web.xml deployment descriptor:

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Listing 1 HotelController.java This class is the session-specific controller. It parses user requests, accesses the model, and decides which view should be delivered back to the client.

```
package dw_travel.hotel;

import java.io.*;
import java.net.*;
import java.util.*;
import javax.servlet.*;
import javax.servlet.http.*;
import dw_travel.common.*;

public class HotelController {
  private ServletContext       context;
  private HttpSession          session;
  private String               realPath;
  private String               nextPage = null;

  private static final String  HOTELS_KEY = "hotels";

  public HotelController() { }

  public void init(ServletContext context,
    HttpSession session) {
    this.context = context;
    this.session = session;
    this.realPath = context.getRealPath("/");
  }

  public void service(HttpServletRequest req) {

    // Extract the command from the request.
    String cmd = null;
    Enumeration names = req.getParameterNames();
    while (names.hasMoreElements()) {
      String name = (String)names.nextElement();
      if (name.startsWith("cmd-")) {
        cmd = name.substring(4, name.length());
        break;
      }
    }

    // Route according to the command.
    if (cmd == null) { unknownCommand(req); }
    else if (cmd.equals("get-cities")) { getCities(req); }
    else if (cmd.equals("get-hotels")) { getHotels(req); }
    else { unknownCommand(req); }
  }

  private void getCities(HttpServletRequest req) {
    this.nextPage = "cities.xml";
  }

  private void getHotels(HttpServletRequest req) {
    String ctryName = req.getParameter("ctry-name");
    String cityName = req.getParameter("city-name");
    Vector hotels = HotelDao.readSpecial(realPath +
      "/WEB-INF/data/hotels.txt", ctryName, cityName);
    session.setAttribute(HOTELS_KEY, hotels);
    this.nextPage = "hotels-xml.jsp";
  }

  private void unknownCommand(HttpServletRequest req) {
    this.nextPage = "error.html";
  }

  public String getNextPage() { return nextPage; }
}
```

Listing 2 hotels-xml.jsp This JSP file dynamically generates XML data. XSL-enabled browsers can apply an XSL stylesheet to the XML in order to render it.

```
<%@ page import="java.util.*, dw_travel.common.*,
dw_travel.hotel.*" %>
<jsp:useBean id="hotels" class="java.util.Vector"
scope="session"/>

<?xml version="1.0"?>
<?xml:stylesheet type="text/xsl" href="hotels.xsl"?>

<hotels>
  <%
    int numHotels = hotels.size();
    for (int i = 0; i < numHotels; i++) {
    Hotel hotel = (Hotel)hotels.get(i);
    Address addr = hotel.getAddress();
  %>
  <hotel id="<%= hotel.getId() %>">
    <name><%= hotel.getName() %></name>
    <address>
      <street><%= addr.getStreet() %></street>
      <city><%= addr.getCity() %></city>
      <state><%= addr.getState() %></state>
      <zip><%= addr.getZip() %></zip>
      <country><%= addr.getCountry() %></country>
    </address>
  </hotel>
  <% } %>
</hotels>
```

```
<web-app>
  <welcome-file-list>
    <welcome-file>
      index.html
    </welcome-file>
    <welcome-file>
      index.jsp
    </welcome-file>
  </welcome-file-list>
</web-app>
```

(In fact, in the deployment descriptor that comes with the online version of the code, we've already done this for you. It should work independently of whether you are using Tomcat.)

Let's look at HotelController more carefully (Listing 1). As noted, HotelController is session-scoped, and each client session has its own instance. HotelController accepts commands (encoded as HTTP parameters in the client request), accesses the model in a way that carries out commands, and then decides which document should be delivered to the client in response. In the case that the client requests the static city data, HotelController doesn't need to access the model at all. It simply sets the page to be delivered to the client to cities.xml, which is just a static file (see Figure 6). If, however, the client requests hotel data, then HotelController loads the hotel data from the data tier (here, just the flat file hotels.txt) and puts it into a Vector of Hotel JavaBeans. Then HotelController puts the Vector on the session scope so that hotels-xml.jsp (Listing 2) will have access to it. Finally it sets the page to be hotels-xml.jsp, which delivers dynamically generated XML to the client (see Figure 7).

The key to interoperability is the fact that HotelController assumes only that the client can process XML. At the time of this writing this is not quite the weak assumption that we make it out to be. It's true that among Web browsers, only IE5 can handle XSLT-based XML processing. But XML-based communication is rapidly gaining popularity. In the meantime, a good solution is to implement server-side browser detection, and deliver HTML (either generated directly by a servlet or a JSP, or else generated by using server-side XSLT) or XML depending upon the browser. This would ensure that our application could interoperate with Web browsers (currently the

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Listing 3 CityMapApplet.java This applet retrieves city data from the network and allows users to choose a city by interacting with an image map.

```
package dw_travel.common.citymap;

import java.net.*;
import java.util.*;
import javax.swing.*;
import dw_travel.common.*;

public class CityMapApplet extends JApplet
  implements CityMapListener {
  private CityDao    cityDao;
  private CityMap    cityMap;

  public void init() {
    ToolTipManager.sharedInstance().setInitialDelay(0);

    // Read hotel data (XML) from the network.
    Vector cities = null;
    try {
      URL url = new URL(
        getCodeBase(), "../?cmd-get-cities=1");
      this.cityDao = new CityDao(url.toString());
      cities = cityDao.read();
    } catch (
      MalformedURLException e) { e.printStackTrace(); }

    this.cityMap = new CityMap(cities, 5);
    cityMap.addCityMapListener(this);
    getContentPane().add(cityMap);
  }

  public void citySelected(CityMapEvent cme) {
    URL url = null;
    try {
      City city = cme.getCity();
      String ctryName = city.getCountry().getName();
      String cityName = city.getName();
      url = new URL(getCodeBase(),
        "../?cmd-get-hotels=1&ctry-name=" + ctryName +
        "&city-name=" + cityName);
      getAppletContext().showDocument(url);
    } catch (
      MalformedURLException e) { e.printStackTrace(); }
  }
}
```

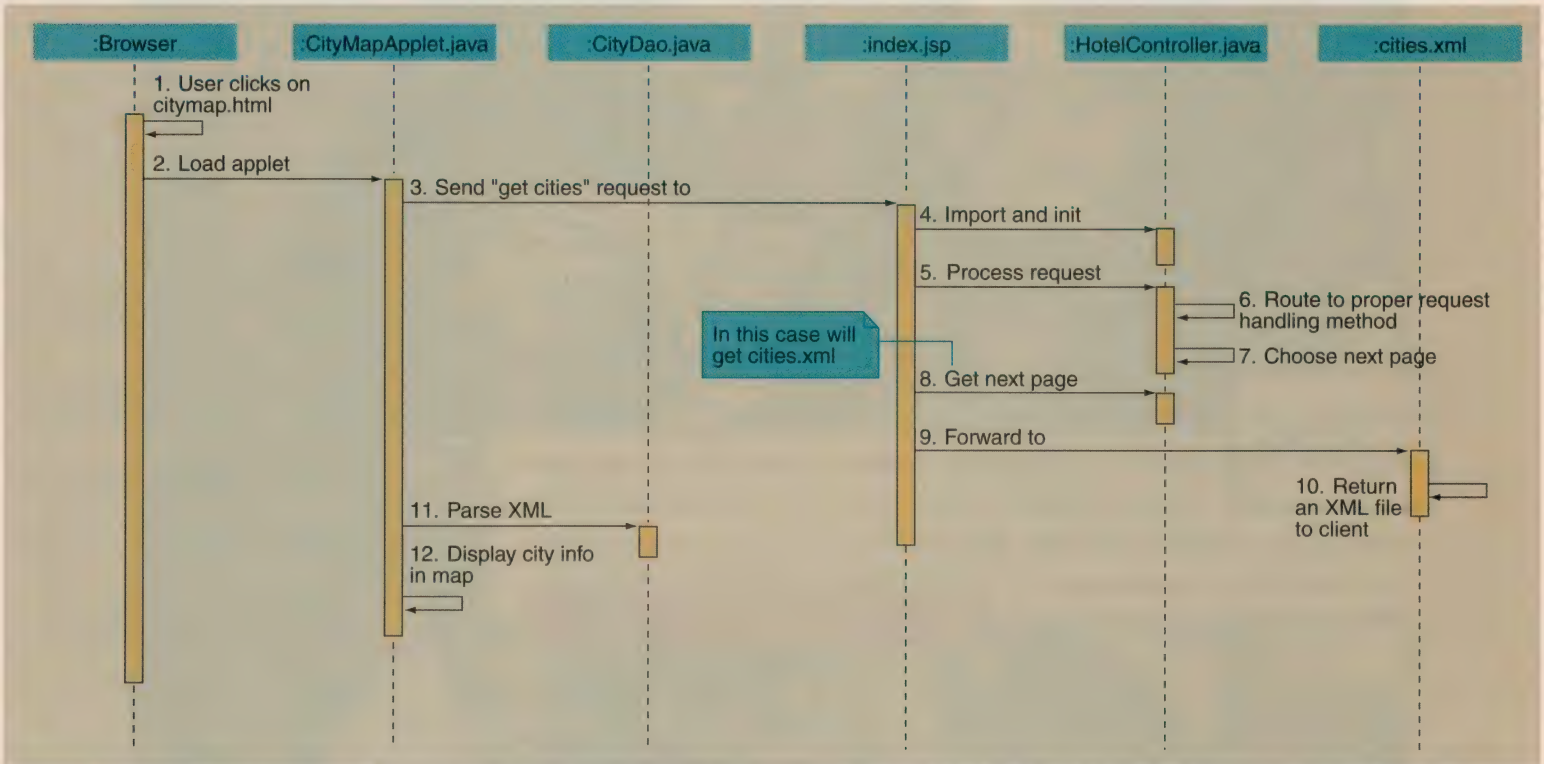

Figure 6 Sequence Diagram (Cities) For the applet client use case, here is the static data source (cities.xml), the events that external actors generate, their order, and intersystem events.

most common kind of client). Here, however, we simply deliver XML and assume that the client can process it.

This discussion therefore addresses the tension between our requiring IE5 for the purposes of this article and our claiming that XML provides a means for achieving interoperability. Using XML does not prevent one from also using HTML.

Applet-Based Presentation

The image map from the second application page is implemented as a Java applet called CityMapApplet (Listing 3), and it displays about 900 cities, for the most part in their correct locations. (Note that we say "for the most part." Students in a data structures course compiled the city data, and they still contain some errors such as reversed latitudes and longitudes, coordinates with the wrong sign, etc.) The applet reads the city data from the server and then renders it. An image of the world (generated by the GNU Generic Mapping Tools) sits underneath the cities. The interaction between the user and the application with respect to the hotel-finding functionality is very simple: The user indicates an interest in finding a hotel, the application presents the user with an interface for selecting a city, the user picks a city, and the application returns a list of hotels in that city (Figure 3). As mentioned earlier, the application has hotel data for only three cities: Los Angeles, San Diego, and Pittsburgh. If you pick any other city, no hotel data will appear.

In real life, it would probably not make sense to use an applet as the *only* way to choose a city, since it is the exception rather than the rule that someone has the Java Plug-in installed in their browser. Even though anybody can download

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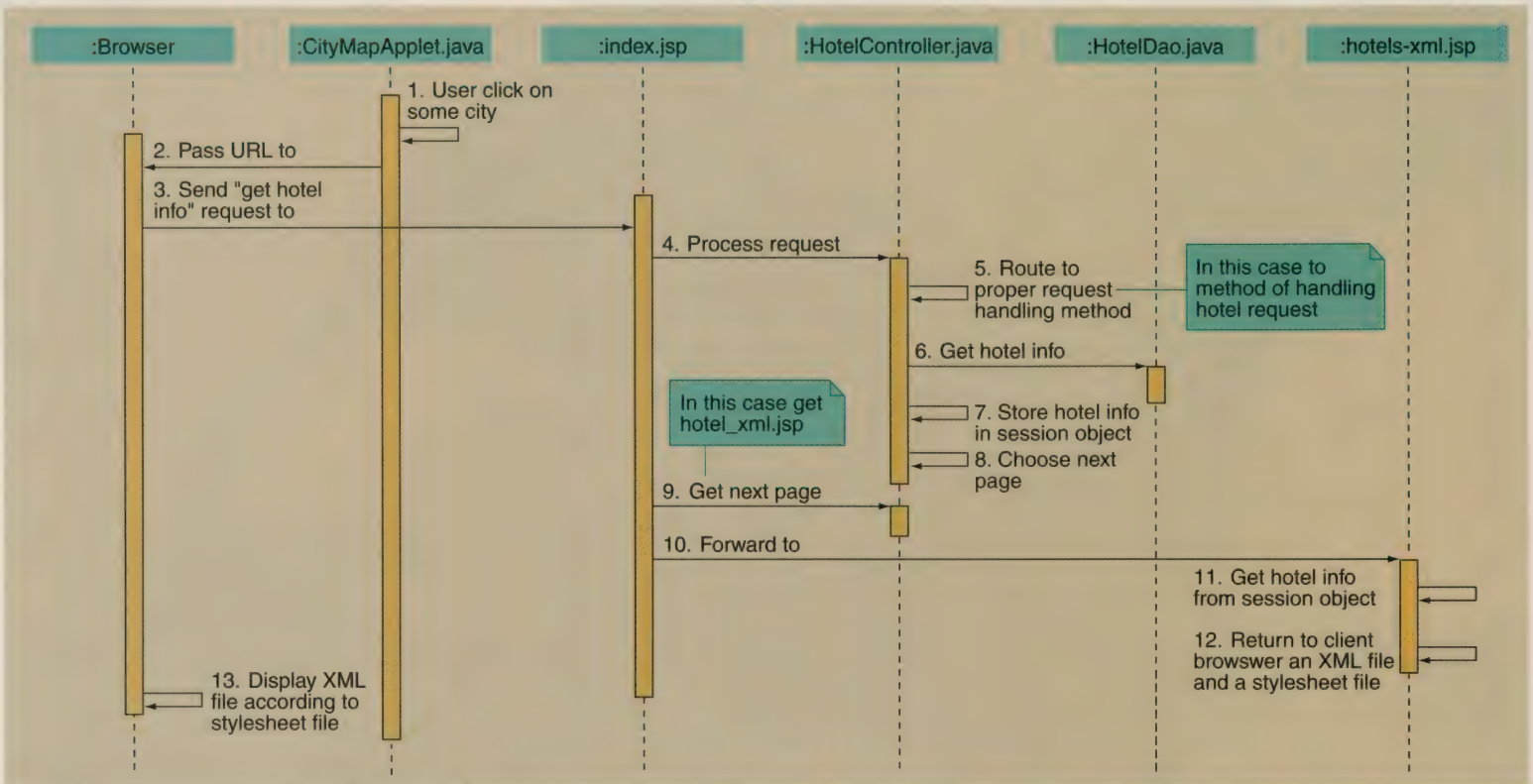
:Browser
:CityMapApplet.java
:index.jsp
:HotelController.java
:HotelDao.java
:hotels-xml.jsp
1. User click on some city
2. Pass URL to
3. Send "get hotel info" request to
4. Process request
5. Route to proper request handling method
In this case to method of handling hotel request
6. Get hotel info
In this case get hotel_xml.jsp
7. Store hotel info in session object
8. Choose next page
9. Get next page
10. Forward to
11. Get hotel info from session object
12. Return to client browswer an XML file and a stylesheet file
13. Display XML file according to stylesheet file

Figure 7 Sequence Diagram for XML Broswer For the XSL-enabled browser user case, here is the dynamically generated XML hotel data, the events that external actors generate, their order, and intersystem events.

it, imposing such a burden on customers when HTML-based alternatives are clearly available would drive most customers to a competitor's site. On the other hand, from a human-to-computer interaction point of view it often makes perfect sense to offer multiple forms of interaction, given that different people have different preferences and that different designs have different usability characteristics. Applets allow the possibility of increased usability. Thus applets should not be rejected as a means for implementing a customer interface. To the contrary, as long as you are careful to provide HTML alternatives, you should look for opportunities to use applets as a way of enhancing the user experience. For simplicity, we didn't implement an HTML-based city picker, but it would be critical to have one in a real-life version of the site. This explains why there is no contradiction in our requiring the Java Plug-in and our achieving interoperability.

Let's look at how CityMapApplet gets its data. CityMapApplet uses a CityDao data access object (Listing 4) to obtain a Vector of cities. CityDao.read() creates a DOM tree (that is, an org.w3c.dom.Document) representation of the XML document located at the URI specified by the applet, which is the URI for the cities.xml file:

```
// uri points at cities.xml
Document document =
  XmlDocument.createXmlDocument(uri);
```

Then it walks the DOM tree to pull out the city information and put it in a Vector. Finally, it returns the Vector.

Note that CityMapApplet reads its XML from a static source (namely the file cities.xml). This is because the application treats city data as being essentially static: If a client requests the city data, it always gets all of the data. There is no way for the client to ask for a subset of the city data. As we shall see, it is possible to generate XML dynamically, and there is nothing different from the applet's point of view in terms of processing it.

Once the applet gets the Vector of cities from CityDao.read(), it is ready to accept user input. When the user selects a city, the applet tells the browser to jump to a URL that takes a city parameter (specified as an HTTP parameter) and returns a list of hotels in that city (given in XML). It does this as follows:

```
url = new URL(getCodeBase(), "../?cmd-
get-hotels=1&ctry-name=" + ctryName +
"&city-name=" + cityName);

getAppletContext().showDocument(url);
```

The applet's AppletContext member is a Java representation of the applet's operating environment (the browser). Java has extremely limited control over the browser (especially when compared to JavaScript), but it does have the important ability to tell the browser to jump to a new URL. This is what the showDocument() method does. Thus, in the previous code snippet, the applet asks the browser to jump (passing HTTP parameters with the request), but it is the *browser* that actually jumps to the new URL and downloads the hotel data appropriate to the passed parameters. This makes sense since the job of CityMapApplet is to allow the user to pick a city. CityMapApplet does not know or care about what the application does with the city once the user has selected it. Thus CityMapApplet can be reused in other contexts where we might need to pick a city.

Browser-Based Presentation

We briefly mentioned hotels-xml.jsp (Listing 2) in our earlier discussion of the Web-tier. This JSP dynamically generates an XML representation of the Vector of hotels that the HotelController put on the session. Since this XML representation contains pure data (that is, it does not contain presentation-related information), we still need a way to attach presentation information to the XML. We do this by having the following line in our XML:

```
<?xml:stylesheet
  type="text/xsl" href="hotels.xsl"?>
```

This tells the XML-enabled client that the hotels.xsl stylesheet (Listing 5) should be applied to the XML data. Thus it is not *exactly* true that the XML representation does not con-

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Listing 4 CityDao.java This data access object is used to parse XML data. It walks the DOM tree and builds a Vector of cities.

```
package dw_travel.common;

import java.util.*;
import com.sun.xml.tree.*;
import org.w3c.dom.*;

public class CityDao {
  private String    uri;

  public CityDao(String uri) { this.uri = uri; }

  public Vector read() {
    Vector cities = new Vector();
    Map countries = new HashMap();

    try {

      // Build the DOM tree from the XML document.
      Document document = XmlDocument.createXmlDocument(uri);

      // Walk the DOM tree to build the Vector.
      Element citiesElem = document.getDocumentElement();
      NodeList cityList =
        citiesElem.getElementsByTagName("city");
      int numCities = cityList.getLength();
      for (int i = 0; i < numCities; i++) {
        Element cityElem = (Element)cityList.item(i);
        String cityName = cityElem.getAttribute("name");
        String fullCityId = cityElem.getAttribute("id");
        StringTokenizer st =
          new StringTokenizer(fullCityId, ":");
        String ctryId = st.nextToken();
        String cityId = st.nextToken();

        // We want to set these properties.
        String ctryName = null;
        Country ctry = null;
        boolean isCap = false;
        double lng = 0.0;
        double lat = 0.0;

        NodeList cityChildren = cityElem.getChildNodes();
        int numCityChildren = cityChildren.getLength();
        for (int j = 0; j < numCityChildren; j++) {
          Node cityChild = cityChildren.item(j);
          if (cityChild.getNodeType() !=
            Node.ELEMENT_NODE) { continue; }

          // We have an element node.
          String n = cityChild.getNodeName();
          if (n.equals("country")) {
            ctryName =
              ((Element)cityChild).getAttribute("name");
          } else {
            String v = null;  // value
            NodeList children = cityChild.getChildNodes();
            int numChildren = children.getLength();
            for (int k = 0; k < numChildren; k++) {
              Node child = children.item(k);
              if (child.getNodeType() == Node.TEXT_NODE) {
                v = child.getNodeValue();
                break;
              }
            }
            if (n.equals("is-capital")) {
              isCap = v.equals("true");
            } else if (n.equals("longitude")) {
              lng = Double.parseDouble(v);
            } else if (n.equals("latitude")) {
              lat = Double.parseDouble(v);
            }
          }

          // Create-if-absent scheme for getting countries.
          ctry = (Country)countries.get(ctryId);
          if (ctry == null) {
            ctry = new Country(ctryId, ctryName);
            countries.put(ctryId, ctry);
          }
        }

        // Add the new city.
        cities.add(new City(cityId, cityName, ctry, isCap,
          lng, lat, "don't care"));
      }

    } catch (Exception e) {    // IOException, SAXException
      System.out.println(
        "CityDao.readXml(): Couldn't read cities.");
      e.printStackTrace();
    }

    return cities;
  }
}
```

tain presentation-related information, since the xml:stylesheet declaration counts as a piece of presentation information. The outcome of this XSL transformation (XSLT) in our case will be a well-formed HTML document (Figure 8), one that abides by XML rules such as having matching start and end tags. Transforming XML to HTML is likely to be the most common use for XSLT for a while, but you should know that there are other possibilities, such as transforming XML into Wireless Markup Language (WML), Scalable Vector Graphics (SVG), MathML, or any other XML-based markup language. Thus to support wireless clients, one needs only to create an XSL stylesheet to convert the XML data into WML. This is a huge interoperability gain.

To apply an Extensible Stylesheet Language (XSL) stylesheet to an XML document, a client must have an XSL processor. Currently IE5 is the only browser with an XSL processor. Though it is beyond the scope of this article to look carefully at XSL, we can give a taste of how it works. XSL is a markup language defined in XML. It has tags with formatting semantics and tags with XML transformation semantics. Since we are transforming the XML into HTML, we will not use the part of XSL concerned with formatting (known as formatting objects). We will instead focus on XSLT.

The root element of an XSL stylesheet is <xsl:stylesheet>. We bind the XSL namespace (located at www.w3.org/TR/WD-xsl) to the xsl: prefix with the xmlns:xsl attribute as follows:

```
<xsl:stylesheet xmlns:xsl=
  "http://www.w3.org/TR/WD-xsl">
```

XSLT is based upon the idea of templates. You can use it to define *template rules*, which are mappings from nodes in the source XML to presentation-related templates. One of the template rules in hotels.xsl specifies an HTML template for <hotel> elements. It is defined using the <xsl:template> element. The value of the match element in the following snippet indicates that this is a template rule for <hotel> elements in the XML source:

```
<xsl:template match="hotel">
<tr>
<td><xsl:value-of select="@id"/></td>
<td><xsl:value-of
  select="name"/></td>
<td><xsl:value-of
  select="address/street"/></td>
<td><xsl:value-of
  select="address/city"/></td>
<td><xsl:value-of
  select="address/zip"/></td>
<td><xsl:value-of
  select="address/country"/></td>
</tr>
</xsl:template>
```

The template can contain arbitrary HTML, as long as it doesn't violate XML well-formedness

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Listing 5 hotels.xsl This is the XSL stylesheet containing the instructions for formatting the XML hotel data. The client browser uses it to perform XSLT. For more information on XSL, please refer to the XSL specification at www.w3.org/Style/XSL/.

```
<?xml version="1.0"?>
<xsl:stylesheet xmlns:xsl="http://www.w3.org/TR/WD-xsl">

  <xsl:template match="/">
    <html>
    <head>
      <link rel="StyleSheet" type=
        "text/css" href="../style.css"/>
      <title>D &amp; W Travel</title>
    </head>
    <body>
    <table width="780" border="0" cellspacing=
        "0" cellpadding="0">

      <!-- Set column widths -->
      <tr>
        <td><img src="../images/dot.gif" width=
          "195" height="1"/></td>
        <td><img src="../images/dot.gif" width=
          "195" height="1"/></td>
        <td><img src="../images/dot.gif" width=
          "195" height="1"/></td>
        <td><img src="../images/dot.gif" width=
          "195" height="1"/></td>
      </tr>

      <!-- Banner -->
      <tr bgcolor="#6699cc">
        <td><img src="../images/dot.gif"/></td>
        <td colspan="3" height="40" align=
          "left" valign="center">
          <table border="0" cellspacing="0" cellpadding="6">
            <tr><td class="verylargesans">
              <font color="#ffffff">D &amp; W Travel</font>
            </td></tr>
          </table>
        </td>
      </tr>

      <!-- Spacer -->
      <tr><td colspan="4" height="6"></td></tr>

      <!-- Content -->
      <xsl:apply-templates select="hotels"/>

      <!-- Footer -->
      <tr>
        <td class="smallsans" align="left" valign="bottom">
          <b>The fine print:</b> Your personal information
            is always safe with us.  We will never sell it
            to a third party without your written consent.
            For more information please read our <a
          href="../dummy-link.html">security policy</a>.
        </td>
        <td colspan="3" class="smallsans" valign="bottom">
          <table width="100%" border="0" cellspacing=
            "0" cellpadding="6">
            <tr>
              <td class="smallsans" align="center">
                <hr/>
                <address>
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                Yunjian</a> and <a href=
                "mailto:wwheeler@andrew.cmu.edu">Willie
                Wheeler</a>.  All rights reserved.
                </address>
              </td>
            </tr>
          </table>
        </td>
      </tr>
    </table>
    </body>
    </html>
  </xsl:template>

  <xsl:template match="hotels">
    <tr>
      <td/>
      <td colspan="3" width="100%" valign="top">
        <table border="0" cellspacing="0" cellpadding="6">
          <tr>
            <td align="left" valign="top">
              <h1 class="largesans">Hotels</h1>
              <table border="1">
                <tr>
                  <th class="sans">ID</th>
                  <th class="sans">Name</th>
                  <th class="sans">Street</th>
                  <th class="sans">City</th>
                  <th class="sans">Zip</th>
                  <th class="sans">Country</th>
                </tr>
                <xsl:apply-templates select="hotel"/>
              </table>
            </td>
          </tr>
          <tr>
            <td class="sans">
              <ul>
                <li><a href="citymap.html">Find
                  another hotel</a></li>
                <li><a href="../index.html">Home</a></li>
              </ul>
            </td>
          </tr>
        </table>
      </td>
    </tr>
  </xsl:template>

  <xsl:template match="hotel">
    <tr>
      <td class="sans"><xsl:value-of select="@id"/></td>
      <td class="sans"><xsl:value-of select="name"/></td>
      <td class="sans"><xsl:value-of select=
        "address/street"/></td>
      <td class="sans"><xsl:value-of select=
        "address/city"/></td>
      <td class="sans"><xsl:value-of select=
        "address/zip"/></td>
      <td class="sans"><xsl:value-of select=
        "address/country"/></td>
    </tr>
  </xsl:template>

</xsl:stylesheet>
```

rules. Templates generally also contain XSL elements that perform transformational work. Here we see that when this template is applied to a <hotel> element, it creates an HTML table row for that element having six columns. The first column contains the value of the <hotel> element's id attribute. The second column contains the value of the <hotel> element's <name> child element. The third column contains the value of the <hotel> elements <street> grandchild (child of <address>), and so forth. This illustrates what is meant by the expression *XSL transformation*: We use an XSL stylesheet to transform the structure of an XML document into a new XML document (in this case, an HTML document that obeys XML rules). XSLT is quite flexible (though not unlimited): it allows you to reorder elements, ignore them, and map them to entire templates.

The template rule for hotels tells the XSL processor what to do once a <hotel> element has been selected, but it does not indicate which <hotel> elements in the source file should be selected. To see how this can be done, we look

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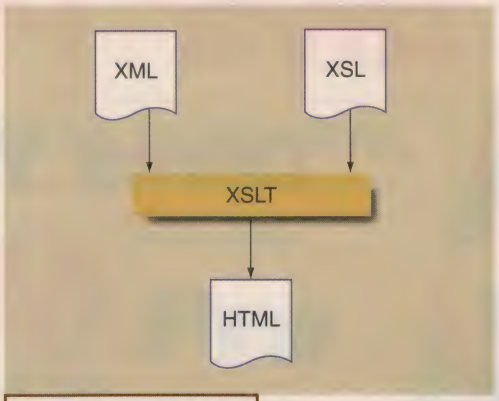

Figure 8 XSLT in Action The most common way of using XSLT is to generate an HTML document by applying an XSL stylesheet to a source XML document.

at the template rule for the source document's root node. This node is matched as follows:

```
<xsl:template match="/">
```

This is the first template rule that the XSL processor will apply (assuming it is defined), since the root node is the first node that the XSL processor will see. The root node template in hotels.xsl contains a lot of HTML, even including a link to a CSS stylesheet. (This is perfectly legitimate.) Toward the middle of the template we see the following lines:

```
<!-- Spacer -->
<tr><td colspan="4"
height="6"></td></tr>
<!-- Content -->
<xsl:apply-templates
select="hotels"/>
<!-- Footer --> [etc.]
```

The <xsl:apply-templates> element, which appears between the spacer table row and the footer information, indicates that it is at this point that the XSL processor should begin applying the <hotels> template rule (careful—not the same as the <hotel> template rule). The point is worth reiterating: Template rules can invoke other template rules. The select attribute allows the XSL processor to be picky about which child nodes cause template rules to be applied. Since the value of the select attribute is "hotels," all <hotels> children of the current *context node* will be selected. Here, the current context node is the document root node since the currently selected template matches the document root node. Our XML data contains only one such child; namely, the <hotels> element. If we look at the <hotels> template rule that appears just below the root node template rule, we see that it constructs an HTML table, and at the appropriate place applies the template rule for <hotel> elements:

```
<table border="1">
  <tr>
    <th>ID</th>
    <th>Name</th>
    <th>Street</th>
    <th>City</th>
    <th>Zip</th>
    <th>Country</th>
  </tr>
  <xsl:apply-templates
      select="hotel"/>
</table>
```

As long as you are careful to provide HTML alternatives, you should look for opportunities to use applets as a way of enhancing the user experience

This causes the <hotel> template rule (that is, the one that generates a table row <hotel> element) to be applied to every <hotel> child of the current context node, which is now the <hotels> element, since the currently selected template matches the <hotels> element.

The net result of all this is an HTML document that presents the data in the XML document in the manner specified by the XSL stylesheet. Once the browser's XSL processor completes the transformation, it renders the resulting HTML document for the client.

In this article we've looked at how to use JSP to serve dynamic content in a way that supports interoperability: serve it as XML instead of HTML. Similarly, we saw that we can achieve interoperability with respect to static content by serving static XML files instead of HTML files. Either way, we can service a much wider range of client types. ■

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A Better Way for Web Development

This Java servlet makes it possible to use XSLT and XML to separate logic and layout during Web development

by Kevin Jones

It has long been recognized that keeping content and logic separate is a good practice. While it is possible to achieve this in many (if not all) development environments, some environments are more conducive to this approach.

Web development teams can be broken into two logical groups: developers and page designers. This scenario seems to lead to an automatic distinction between the business logic and data produced by the developers, and the display managed by the graphic artists. Unfortunately, as many people are aware, keeping the business logic and the HTML production separate is very difficult in practice.

In the world of J2EE, Sun encourages us to keep logic and layout separate. They suggest that you use servlets and JavaBeans for the logic, and JavaServer Pages (JSP) for the layout. However it is very easy to get drawn into mixing logic with layout. For example, the HttpServletResponse has a write() method that is used to send a text response back to the client. This response is typically HTML. Conversely, in JSP, we can add "scriptlets" which are actually blocks of Java code.

In this article we will examine the use of XML and XSLT to help enforce the separation of logic and layout—with XSLT providing the layout.

Kevin Jones is a UK-based instructor for Developmentor, a training firm based in Torrance, California. A developer with more than 15 years of experience, he has spent the last four years researching and teaching Java programming and most recently investigating HTTP and XML. He wrote the "Essential Web Applications: for Java Technologies" class for Developmentor and teaches that course and the "Essential XML" class. Kevin can be reached at kevinj@develop.com or through http://kevinj.develop.com.

XML

There are many good reasons for choosing XML—not least of which is that everybody else is using it! XML has rapidly become the lingua franca of the computer world (even more-so than Java). XML is easily understood by human beings and computers—both can parse XML reasonably efficiently. There are many tools available that allow us to manipulate XML, such as editors, processors (parsers), and databases. The W3C has also produced a specification for the transformation of one XML tree into another. If we regard DHTML as a form of XML, then it is possible to easily turn XML input into DHTML output—just what we need.

The XML specification (www.w3.org/TR/1998/REC-xml-19980210) defines a standard way of representing structured data. The data is represented (mostly) as elements and attributes.

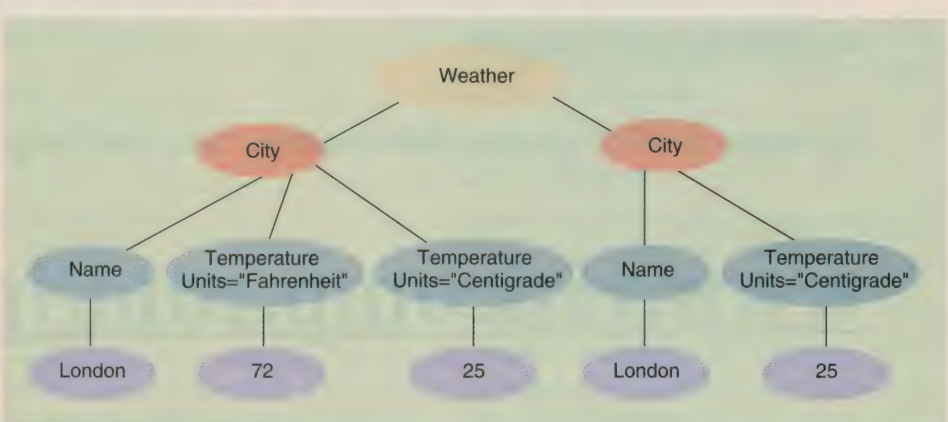

Figure 1 Climbing the Tree The XML specification defines a standard way of representing structured data. The data is represented (mostly) as elements and attributes. This tree diagram shows our XML code.

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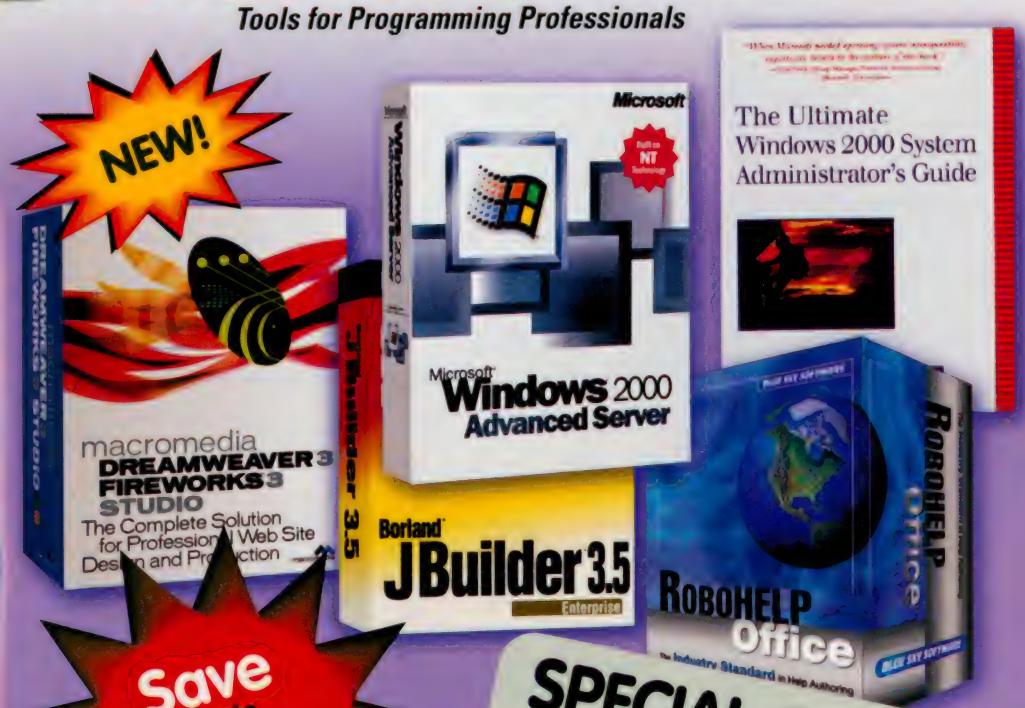

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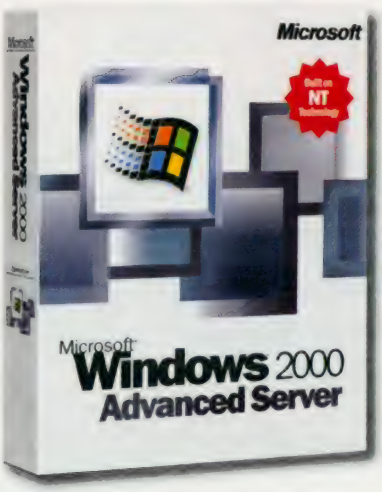

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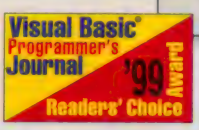

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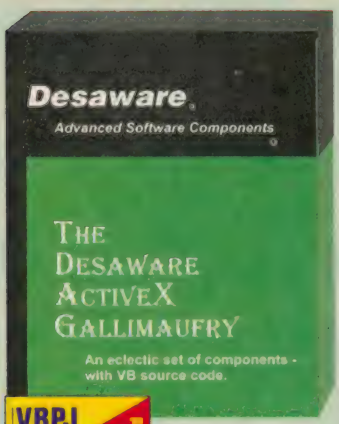
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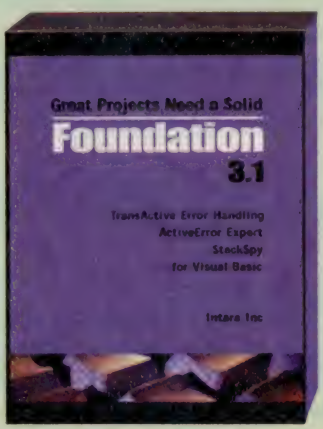

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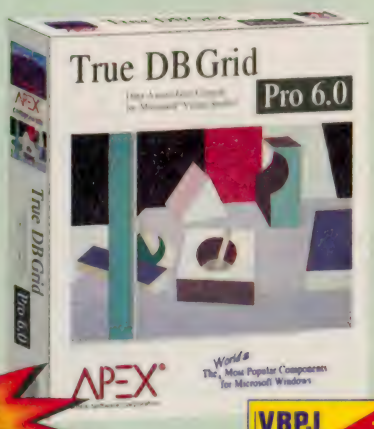

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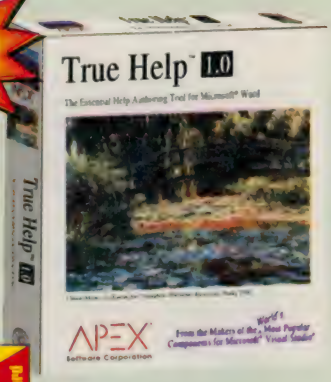

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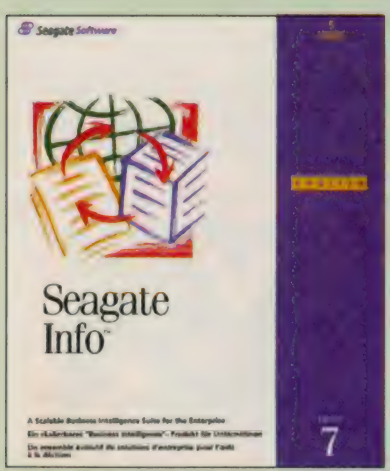

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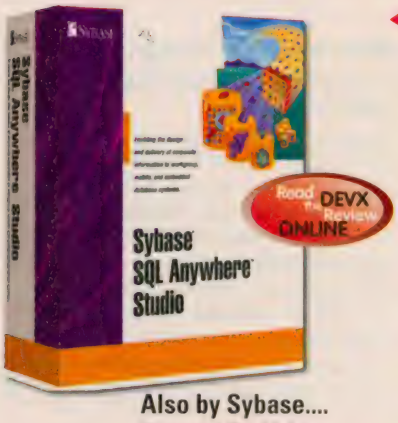

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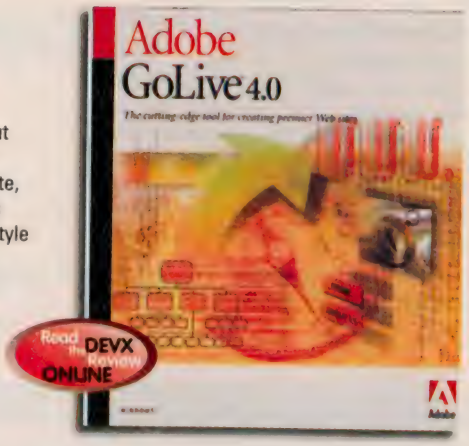

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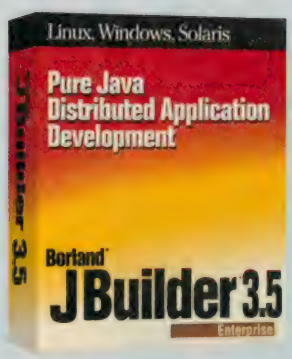

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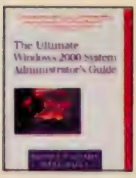

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TOOLS FOR PROGRAMMING PROFESSIONALS

Listing 1 A Slice of XSLT An XSLT processor will take as input an XML document and an XSLT stylesheet. The processor will apply the rules in the stylesheet to the XML document. Rules are specified as part of template elements. A typical XSLT document opens with a stylesheet element and contains many template elements. The template elements contain XPath expressions that match elements in the input XML document.

```
<?xml version="1.0"?>
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/
Transform">

  <xsl:template match="Weather">
    <HTML><BODY>
    <H1>The Weather</H1>
    <ul>
      <xsl:apply-templates />
    </ul>
    </BODY></HTML>
  </xsl:template>

  <xsl:template match="City">
    <li>
      <xsl:value-of select="Name" /> -
      <xsl:apply-templates select=
        "child::Temperature[@Units='Centigrade']"/>
    </li>
  </xsl:template>

  <xsl:template match="Temperature">
    <xsl:value-of select="." />
  </xsl:template>


</xsl:stylesheet>
```

```
<Weather>
  <City>
    <Name>London</Name>
    <Temperature Units=
      "Fahrenheit">72</Temperature>
    <Temperature Units=
      "Centigrade">25</Temperature>
  </City>
  <City>
    <Name>LA</Name>
    <Temperature Units=
      "Centigrade">25</Temperature>
  </City>
</Weather>
```

In this example <City> and <Name> are elements and Units is an attribute. XML defines a set of constraints that define what can go where. These are called well-formedness constraints. For example, there can only be one document (or root) element, <Weather> in this case, and we can't have nested elements, so would be illegal XML. There are many other constraints that a well-formed XML document must follow. An XML processor will fail to parse XML that is not well-formed. (In fact, this is something of an oxymoron: XML is only XML if it is well-formed, otherwise it is just text.)

The previous XML code can be represented as a tree, and indeed the W3C has a specification that lets us do just that—the DOM or Document Object Model in Figure 1 is a representation of that tree.

XSLT

XSLT (www.w3.org/TR/xslt) is a programming language that is XML. XSLT grew out of the work on the XML Stylesheet Language, a form of XML that is used to specify how elements on a page should be laid out. XSLT is a transformation language, and is used to transform an XML input tree into a different XML output tree.

XSLT works by applying transformation rules to parts of the XML input tree. An XSLT program specifies a set of rules and what should be produced if those rules are matched in the input XML. If the XSLT processor finds a match, it executes the XSLT "code."

Rule matches are specified by using another specification produced by the W3C—XPath.

XPath

XPath (www.w3.org/TR/xpath) is a specification that addresses items in an XML tree. It specifies how, given an XML document, you could manipulate or extract information from a given piece of that document, when that given piece could be an element, attribute, or some other XML construct such as an entity, processing instruction, or comment. XPath is so-called because its syntax is very similar to file and directory (or path) manipulation on various operating systems, such as Windows and UNIX.

XPath expressions are resolved relative to the "current" node or to the root node. To specify that the expressions should be evaluated to the root node, the expression starts with a "/". XPath expressions are evaluated relative to a specified axis. Commonly used axes are child and descendant, and there are also several others.

Given the XML tree shown in Figure 1, /child::Weather would return a node set containing the Weather node. /descendant::Temperature would return a node set containing the three Temperature nodes. XPath expressions can be compounded, so /child::Weather/child::City/child::Name would return the node set containing both Name nodes.

As many people are aware, keeping the business logic and the HTML production separate is very difficult in practice

XPath expressions can contain predicates that filter the node set, so /child::Weather/child::City[child::Temperature=?25?] would return all City nodes whose Temperature children contained the value 25.

XPath expressions can also be abbreviated. The default axis is the 'child' axis, so leaving out the axis name in the location path means 'child::/' – /Weather/City/Temperature is equivalent to /child::Weather/child::City/child::temperature.

Using XPath in XSLT

An XSLT processor will take as input an XML document and an XSLT stylesheet. The processor will apply the rules in the stylesheet to the XML document. Rules are specified as part of template elements. A typical XSLT document opens with a stylesheet element and contains many template elements. The template elements contain XPath expressions that match elements in the input XML document.

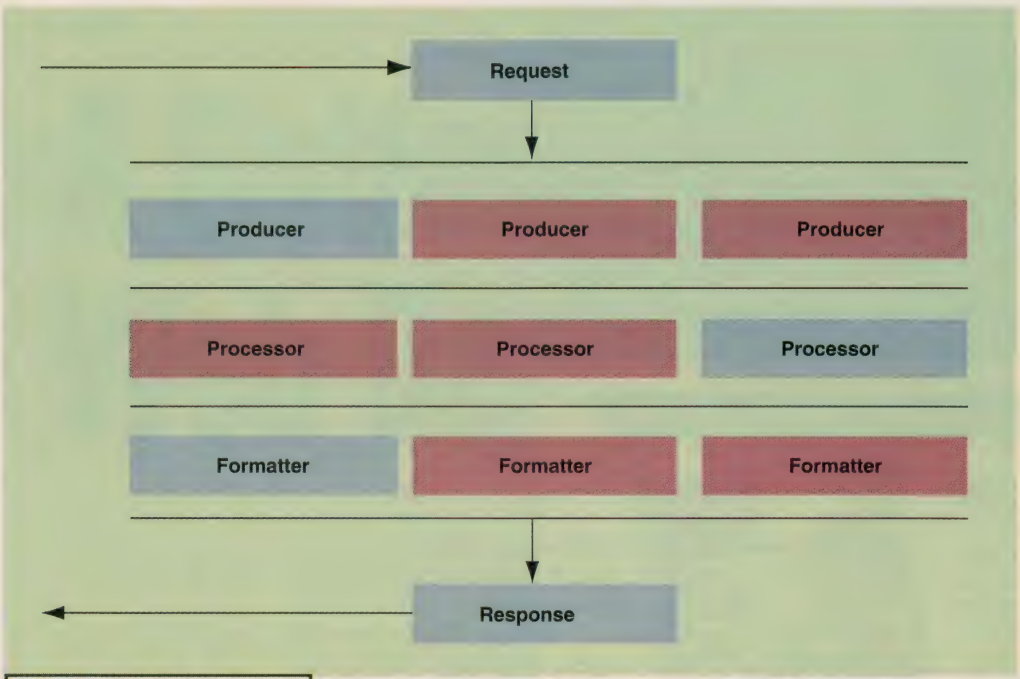

Figure 2 Cocoon Architecture The Cocoon architecture is based on a pipeline-like model. The request from the client enters and is passed through a producer, to a processor, and on to a formatter. The response is then sent back to the client.

Listing 1 shows an XSLT example. This template starts processing at the Weather element and outputs the HTML tags:

```
<HTML><BODY>
  <H1>The Weather</H1>
  <ul>
```

The apply-templates() method is then called, which tries to match any XPath expressions with nodes in the input XML tree. Remember that if there is no leading "/" the XPath expressions are relative to the current context, and that child is the default axis.

The next match is therefore City (or child::City) that outputs the value of the Name element (<xsl:value-of select=?Name?>) and tells the processor to match any child temperature nodes that have an attribute whose name is Units and whose value is Centigrade (<xsl:apply-templates select="child::Temperature[@Units='Centigrade']"/>).

Finally the temperature node is matched, and its value is output. This gives a resultant XML tree of:

```
<HTML>
<BODY>
<H1>The Weather</H1>
<ul>
  <li>London -
    25</li>
  <li>LA -
    25</li>
</ul>
</BODY>
</HTML>
```

Processing XML/XSLT

So where are we? XML serves as our standard data interchange format between developers and designers, and XSLT provides designers with a formal way to turn the XML input into DHTML output. Several questions remain though. Where do I process the XML/XSLT? Should it be done at the server or the client? How do we do the XML/XSLT processing? What tools let us do this? How do we produce the XML? Can we produce it dynamically? Let's take a moment and answer these questions.

Ideally, we would like to carry out the XML/XSLT processing at the client to ease the load on the server. The current release of Internet Explorer (version 5) allows us to do this. There are two problems, however. The first is that not everyone has IE5. The second problem is that IE5 currently supports a version of XSLT that is at least 18 months old! So, if we want our program to work with as many browsers as possible, we should run the XML/XSLT transform at the server.

As previously mentioned, processing at the server has at least one major drawback: the load on the server may be substantial. However, there are also advantages. The server is a well-known environment. For example, we know what versions of software are available and we know what OS we are running on. We may have little or no control over the clients, and their respective software, that will be visiting our site.

When processing XML/XSLT, we have various processors to pick from. The Apache Software Foundation has an XML processor (called Xerces) and an XSLT processor (called Xalan). Xalan will take as input an XML document and an XSLT document, run the transform, and produce XML as output. All we would have to do is write a servlet that takes a request, instantiates Xalan, and sends the resultant HTML back to the client.

Writing a servlet ourselves wouldn't be difficult but there are certain issues we should address. We've said that the load on the server may be high, so how about having a caching mechanism on the server that stores already transformed XML? If I have a servlet that will transform XML, where does the input XML come from? We should have a mechanism that allows dynamic XML production. What if the client didn't want to process HTML? Could we design a servlet that would let us plug in different output formatters such as PDF?

Listing 2 Inside the Cocoon In the Cocoon architecture, the request from the client enters and is passed through a producer, to a processor, and on to a formatter. Producers produce an XML document, processors work on the produced document, and formatters format the output ready to be sent back to the client. Formatters and processors are associated with an XML document via XMI Processing Instructions. This listing was taken from the Cocoon examples.

```
<?xml version="1.0"?>

<?cocoon-process type="ldap"?>    <!-- use the
  ldap processor -->
<?cocoon-format type="text/xml"?> <!-use the
  xml formatter -->

<page>

  <ldapdefs>
    <server name="searchlight">
      <initializer>com.sun.jndi.ldap.LdapCtxFactory</initializer>
        <ldapserverurl>ldap://dir.skyway.nsa:389</ldapserverurl>
        <ldapsearchbase>o=U.S. Government, c=US</ldapsearchbase>
    </server>
  </ldapdefs>

    <query server="searchlight">
    uid=jmbirch
    </query>

  </page>
```

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Listing 3 Make a Connection In our example we create a database connection, create a statement, execute the statement, and get back a java.sql.ResultSet. The connection can be made in init() and held onto for the lifetime of the producer. In our InstructorProducer class we define a variable to hold the database connection, and in the init() method we establish the connection shown here.

```
public void init(
  org.apache.cocoon.framework.Director director)
{
  super.init(director);
  try
  {
    // client loads the driver
    Class.forName(
      "sun.jdbc.odbc.JdbcOdbcDriver");
    // specify the connection
    String url = "jdbc:odbc:Instructor";
    // and make the connection
    m_connection =
      java.sql.DriverManager.getConnection(url);
  }
  catch(Exception e)
  {
    // do what all good java programmers do with
    // the exception :-)
  }
}
```

Listing 4 Processing the Results If the SQL query in our application is successful, the following code processes the result set.

```
    str.append("<?xml-stylesheet href=
      \"./instructor.xsl\" type=\"text/xsl\"?>");
    str.append("<?cocoon-process type=\"xslt\"?>");
  str.append("<INSTRUCTORS>");

    while(rs.next())
    {
      str.append("<INSTRUCTOR>");
      str.append("<NAME>");
      str.append(rs.getString(1));
      str.append("</NAME>");
      str.append("<SIZE>");
      str.append(rs.getString(2));
      str.append("</SIZE>");
      str.append("</INSTRUCTOR>");
    }
    str.append("</INSTRUCTORS>");
    System.out.println(str);
  }
  catch(Exception e)
  {
  }
```

Using Cocoon

The task is now a little more interesting, and thankfully somebody has already thought of these issues. The Apache group has a Java servlet called Cocoon, originally written by Stefano Mazzocchi, who is now the chief architect on the project. Cocoon is available from http://xml.apache.org/cocoon/index.html. The latest version at the time of this writing is 1.7.2, with version 2 close on the horizon.

The Cocoon architecture is based on a pipeline-like model (see Figure 2). The request from the client enters and is passed through a producer, to a processor, and on to a formatter. The response is then sent back to the client.

Producers produce an XML document—we will see in a moment how that is done. Processors work on the produced document (for example, they might run an XSLT transform on it), and formatters format the output ready to be sent back to the client. Formatters and processors are associated with an XML document via XML Processing Instructions. (A PI is out-of-band information that's passed by the XML parser to the application that instigated the parse. In our case that application is Cocoon.) So an XML document may look like Listing 2. So each producer, processor, and formatter has a name that is associated with code to be executed.

The default producer for Cocoon is the file producer. When a request comes into Cocoon, the file producer is executed (unless the request specifies otherwise). The file producer code is in the org.apache.cocoon.producer.ProducerFromFile java class. So browsing to http://somerserver/someapp/weather.xml will cause the file producer code to execute. Load the weather.xml file and process it.

If all of your data is statically defined, then the previously described procedure is fine. All the XML can be kept in static files that can be processed, and the output will be handed off to the client. But what if your data isn't static? What if you need to create the data based on information in the request? What if the data is coming from a live feed, and you are trying to present that to the user as HTML? For dynamic data you have two choices: write a producer or write a processor.

XML is easily understood by human beings and computers—both can parse XML reasonably efficiently

How to Write a Producer

A producer is code that will be executed when a specific type of response comes in from the client. The producer will create (produce) XML and add to the XML the instructions that Cocoon needs to further process that XML.

Cocoon defines a set of interfaces and classes that we use to write producers. These are all grouped together in the org.apache.cocoon.producer package. There's a single interface (producer) and four classes, two of which are implementations of producers (the file producer and the request producer).

The org.apache.cocoon.producer.Producer interface is the base of all producers in Cocoon. It has getStream(), getDocument(), and getPath() methods. We will rarely, if ever, implement Producer directly. Instead we use a helper class, AbstractProducer.

We generally extend the class org.apache.cocoon.producer.AbstractProducer to write producers. This class is a standard part of the Cocoon architecture. It implements both org.apache.cocoon.producer.Producer and org.apache.cocoon.Defaults as well as extends org.apache.cocoon.framework.AbstractActor.

AbstractProducer is, as its name suggests, an Abstract class. It implements getDocument(), leaving us to implement getStream() and getPath(). getPath() returns the location of the XML resource, or an empty string if no sensible path can be applied to the resource. In our case, we will return an empty string. getDocument() is called by the Cocoon framework to retrieve the XML document. The AbstractProducer implementation of this method instantiates a parser and calls getStream() to load the XML into the parser. getStream() is the method that produces the XML document. It returns a java.io.Reader that contains the XML. This is the method that we write.

So, our producer will extend AbstractProducer and implement the getPath() and

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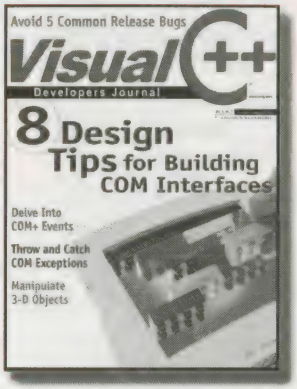
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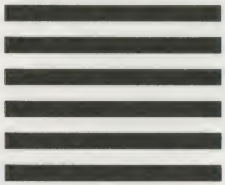

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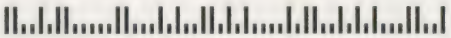

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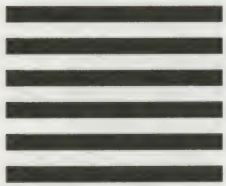

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Listing 5 What, Where, When This extract taken from Cocoon.Properties provides information about the XML producers, processors, and formatters and when they should be used.

```
##########################################
# XML Producers                          #
##########################################

# For example, if you want to produce your XML template
# reading it from the file system, using your producer, you
# should request the URI:
#   http://your.site.com/your_XML_file.xml?producer=file

# This is the request parameter used to identify the
# producer in the request:
# (default value is "producer")
producer.parameter = producer

# The syntax for this is
#   producer.type.xxx = full.class.name
# where "xxx" is the producer identifier used in the request
producer.type.file =
org.apache.cocoon.producer.ProducerFromFile
producer.type.request =
org.apache.cocoon.producer.ProducerFromRequest
producer.type.instructor = com.develop.InstructorProducer

# This is used in the example files
producer.type.dummy = org.apache.cocoon.example.DummyProducer

# When producer indication is present in the request
# this configuration allows us to map those requests to a
# particular producer indicated here with its type.
# NOTE: this type must present in the above map.
producer.default = file
#
# CUT HERE
#

##########################################
# XML Formatters                         #
##########################################

# These are used when the <?cocoon-format type="xxx/yyy"?>
# PI is present. The syntax for this is
#   formatter.type.xxx/yyy = full.class.name

formatter.type.text/xml    =
org.apache.cocoon.formatter.XMLFormatter
#
# CUT HERE
#
##########################################
# XML Processors                         #
##########################################

# These are used when the <?cocoon-process type="xxx"?>
# PI is present. If no PI of that type is present, no
# processing is performed. The syntax for this is
#   processor.type.xxx = full.class.name

# XSL Transformations (XSLT)
processor.type.xslt =
org.apache.cocoon.processor.xslt.XSLTProcessor

# SQL Processor
processor.type.sql =
org.apache.cocoon.processor.sql.SQLProcessor

# LDAP Processor
processor.type.ldap =
org.apache.cocoon.processor.ldap.LdapProcessor
```

getStream() methods. getPath() (in the simplest case) is trivial, but getStream() is where the work gets done:

```
public class InstructorProducer extends
  AbstractProducer

{

  public String getPath(
    javax.servlet.http.HttpServletRequest
    request)
  {
    return "";
  }
}
```

A typical use for a producer may be to run a query against a database with a fixed number of parameters in the response. For example:

```
"SELECT instructor, size FROM
  INSTRUCTORS WHERE size > ?"
```

where "?" is passed in the request. In this case we would run the query and then turn the result into XML. The XML would always follow the same schema. It would only contain instructors and sizes, and so the XSLT to process would also be fixed. We would write this code inside getStream().

Initialization

In our example we create a database connection, create a statement, execute the statement, and get back a java.sql.ResultSet. But it's the processing of the result set that interests us. The connection can be made in init() and held onto for the lifetime of the producer. In our InstructorProducer class, we define a variable to hold the database connection:

Cocoon provides a framework within which we can perform the processing that is required when mixing XML and XSLT

```
java.sql.Connection m_connection;
```

and in the init() method we establish the connection shown in Listing 3. Note that we are using the ODBC bridge driver. I would not recommend this for production code, but it is easy to test out the producer using this driver.

The getStream() method needs to return a java.io.Reader that contains the XML to be transformed. In our case, this will consist of an XML outline and the results of the database query.

The first thing we need to do is to declare and initialize two variables that will be used in the method:

```
public java.io.Reader getStream(
  javax.servlet.http.HttpServletRequest
  request)
{
  java.sql.ResultSet rs = null;
  StringBuffer str =
  new StringBuffer(
  "<?xml version=\"1.0\"?>");
```

rs will hold the results of the query, and str will hold the XML we generate.

The getStream() method is passed to the HttpServerletRequest object, which contains the request parameters (amongst other things) that we can use in our query:

```
  String param =
    request.getParameter("size");
  if(param == null)
    param = "0"; // get everything if no
                 // 'size' parameter
```

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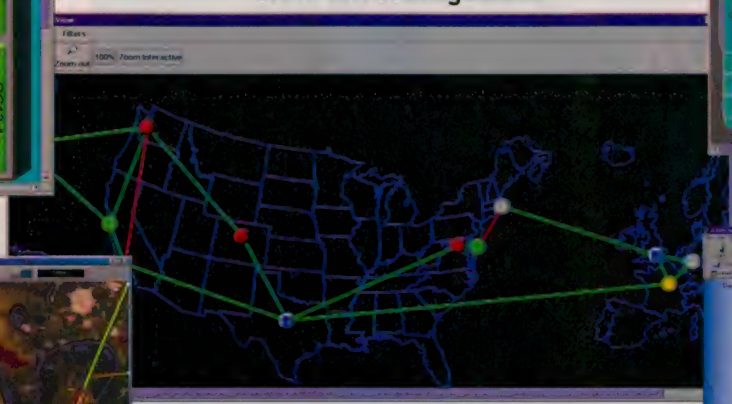

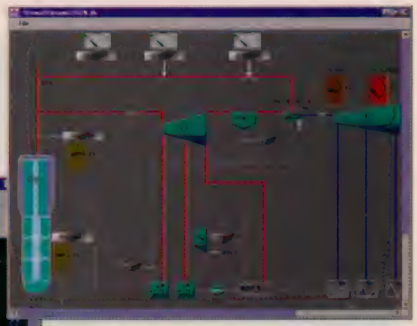

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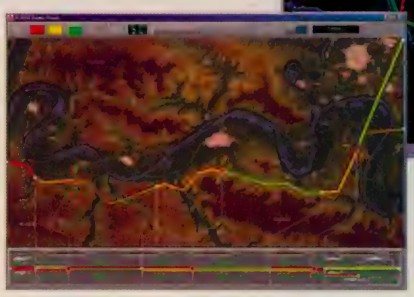

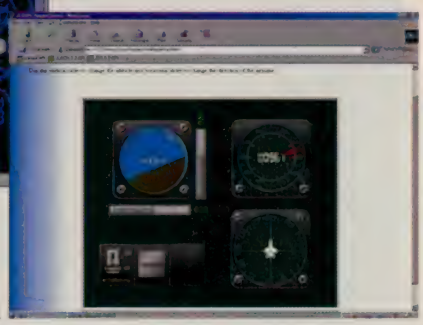

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```
rs = stmt.executeQuery(
  "SELECT NAME, SIZE FROM INSTRUCTOR
  WHERE SIZE > " + param);
```

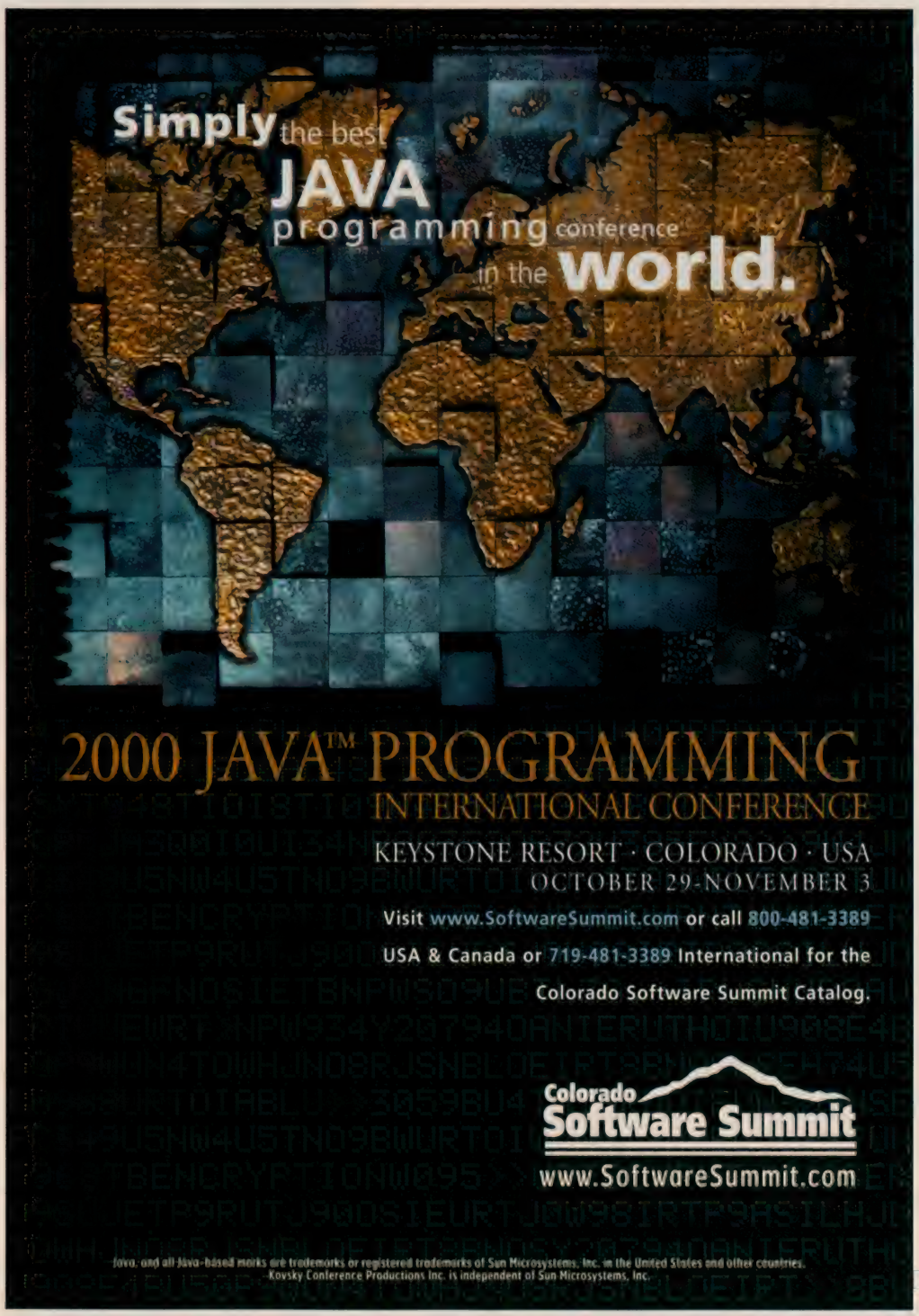
We then want to run the SQL query:

```
try
{
  java.sql.Statement stmt =
    m_connection.createStatement();
  rs = stmt.executeQuery("SELECT NAME,
    SIZE FROM INSTRUCTOR WHERE
      SIZE > " + param);
```

```
http://localhost/xsl/instructor.xml?
  producer=instructor&size=10
```

If the query was successful we can now process the result set, as shown in Listing 4. And finally, we can pass the XML out through a StringReader object:

```
  return new java.io.StringReader(
    str.toString());
}
```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And that's it. All we need to do now is tell Cocoon how to find the producer.

Helpful Hints

Cocoon has a properties file that it reads during startup (cocoon.properties). This file contains information about which XML and XSL processors to use. The important thing is that this file contains information about the producers, processors, and formatters Cocoon should load and when they should be used.

Listing 5 shows an extract from the cocoon.properties file. The producers section says that the default producer is "file" and that to use other producers the producer request parameter must be used (the syntax of the request is http://someserver/someapp/data.xml?producer=instructor). The properties file also matches producer names (instructor in the example here) against a Java class. When we write a producer we need to add an entry to this file, specifying the name of the producer and the Java code to be loaded for that producer.

Similar information is supplied for processors and formatters, but remember these get executed in response to processing instructions in the produced XML document.

When doing Web development, keeping logic and layout separate is a commendable (although not always attainable) aim. Using XSLT and XML allows us to take large steps toward this separation, where XML contains the data and XSLT contains the layout. Cocoon provides a framework within which we can perform the processing that is required when mixing XML and XSLT and provides facilities to allow us to extend the basic processing model.

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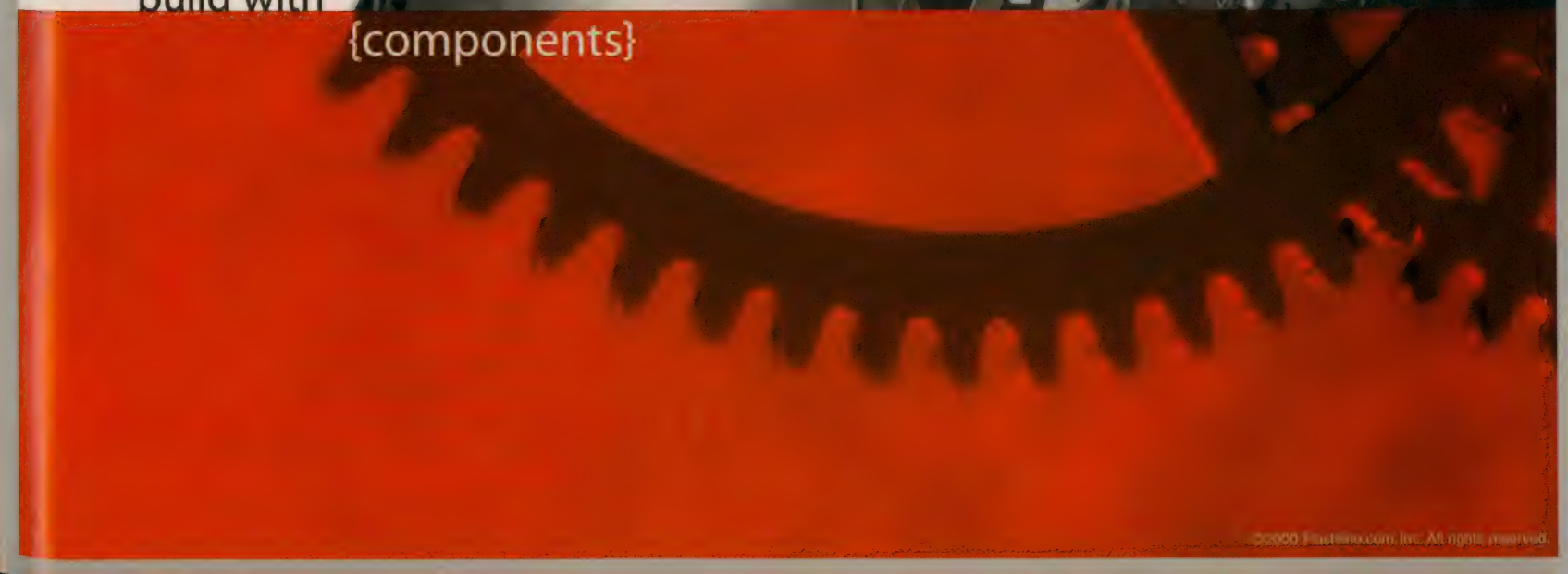

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Measuring the Maturity of Software Engineering

Object-oriented techniques could lead to the maturity of software engineering, which just might help keep your programs from crumbling into a heap

BY JAMES W. COOPER

Last week I went to a talk where the speaker, a well-known software technologist, made the assertion that software engineering is still an immature discipline. I started to wonder about that as I looked around the room and saw a bunch of typical compu-geeks with funny looking hair, dirty jeans, and sloppy T-shirts. Maybe, I thought, it is not software engineering that is immature, but software engineers.

Think about other sorts of engineering: electrical, civil, and so forth. These engineers build concrete products using well-defined disciplines, and following well-known building or electrical regulations. But software engineers don't build anything very concrete. How many programmers does it take to screw in a light bulb? None! That's a hardware problem.

Engineers have disciplines. They wear white shirts, work regular daytime hours, and are rewarded for designing and constructing real things. Programmers (whom I assume are the same as software engineers) make it a point to keep weird hours, play loud music, and wear nontraditional garb whenever they can. Bridges, buildings, circuit boards, and chips work mostly as designed. Software, on the other hand, doesn't work very well. It frequently presents a quirky, idiosyncratic interface, crashes a lot, and annoys users at least as much as it rewards them. Thank goodness we aren't building airplanes. Software crash kills thousands!

Programming isn't a new discipline. If you believe that Ada Lovelace was the first programmer, it is more than 100 years old. I've been writing programs for more than 30 years. My kids grew up faster than that.

Lots of real, concrete things are driven by software these days: cars, washing machines, mixers, CD players. They all work quite well. (If cars crashed as often as Windows, we wouldn't be a commuter society.) But construction of cars is supervised mostly by automotive engineers, not software engineers. Shrink-wrapped software is built by programmers who are not part of the larger discipline enforced by concerns of safety and other regulations.

The Programmer

Why is software so awful? Are programmers as lazy and indolent as all that? Are they just illustrating the stereotype they are expected to conform to? Everyone knows that we programmers are strange. Maybe the fact that we make strange products isn't so surprising. If it's OK to come in at noon and work until midnight, play loud music in your office, and eat junk food all day, maybe producing junky sleep-deprived software isn't such a surprise.

Maybe programmers do what is expected of them. Bosses tolerate bad habits because programmers are smart and can wrangle code—and bosses can't. Maybe part of the problem is that bosses have no idea how to quantify what is going on in programming departments. They just see acres and acres of modules with an unknowable number of defects. All non-trivial programs have at least one undiscovered bug. A sufficient case for program triviality is that the program has no bugs. Sadly this is nearly always the case.

In fact the rumors of 60,000 bugs in Windows 2000 is bizarre. We know there aren't really that many, or the thing wouldn't work at all. On the other hand, we suspect the number of actual bugs is still large. One of the main bugs in Windows NT was the infamous Blue Screen of Death. Windows 2000 is supposed to be much more stable, but it has 13 pages in the small installation guide on how to deal with the blue screen when it strikes. Ah, progress. It's not a bug, it's a feature. I read that the next version will provide these screens in a choice of decorative colors.

Microsoft is well known for working its programmers outrageously long hours with the promise of eventual stock options if you can last it out. Does this lead to more quality, or more potato chips and Twinkies?

Lest you think that Microsoft is the only vendor with problems in programming management, I spent two days looking for a bug in an established and unchanged system that failed, it turned out, because I'd installed the release version of Java 1.2.2. Installing the *beta* of 1.3 (er, that is, a "release candidate") fixed the problem. This does not lead us to great confidence in the stability of anybody's commercial software.

When you install the preview version of Netscape 6, it installs Java 1.3 (preview?!), and thereafter if you run any JVM you get the reassuring error message: Version should be 1.2 but registry is 1.3. Uh-oh.

One place that is spending a lot of time on code robustness is

Resources

Arthur J. Riel, *Object Oriented Design Heuristics*, Addison-Wesley, 1996.

Kent Beck, *Extreme Programming Explained*, Addison-Wesley, 2000.

James Cooper, *Java Design Patterns: A Tutorial*, Addison-Wesley, 2000.

Steve McConnell, *After the Gold Rush*, Microsoft Press, 1999.

Martin Fowler, *Refactoring—Improving the Design of Existing Code*, Addison-Wesley, 1999.

the IBM Centre for Java Technology Development in Hursley, England (see www.ibm.com/java for details). They currently provide a version of the 1.1.8 JVM that is both extremely robust and has very high performance—it includes IBM's own JIT compiler. It's not quite at the Java 2 level, but it is very stable. In fact, I found that using this Java 1.1.8 JVM solved several database access instabilities that had been driving me nuts.

Programmers deal in wishes and ideals more than hard products. If all you have to do is make some code that does something, who is to say what the standards for completeness and correctness really are?

Maybe the problem is that software companies have discovered that customers are not really willing to pay enough for quality. It's better to ship the beta. This is rather like an instrument company I once worked for, where the engineers carefully built a model of the product the assemblers were supposed to replicate for customers. Then what did management do? They shipped the model to the first customer and let the assembly department scramble.

What Price Quality?

So what do we have to pay for quality? Two, or three, or ten times as much? Are we still writing tangles of pasta in the C language? Can Java help us out of this bind? Can the OO disciplines of Design Pattern use, UML design, or simple things like unit testing help? Would it make a difference if we had more mature programmers and managers?

OK, maybe the scraggly clothes crowd isn't at fault. Maybe they only respond to the demands of the pointy-haired boss. Licensing software engineers might not necessarily eliminate this problem. Besides, how can you license software engineers? Software engineering isn't a mature enough discipline yet. Yeah, I heard that before. Booga booga. We'll just scare the bugs away. Call the Orkin man!

Everyone knows that we programmers are strange. Maybe the fact that we make strange products isn't so surprising

Maybe we need to start writing code in better languages like Java. Java might be part of the solution as we move to using it more pervasively. It is embedded in robots, in servers, and even in the devices we once thought would have just a few bytes of ROM. You can build really elegant systems in Java that scale pretty well and don't come crashing down. That is, if the JVM doesn't come crashing down.

We can write much better code in Java just because it *makes* us use OO techniques. If we spend some time thinking about the objects that make up our system, we can write pretty good code. If we take the time to recognize the desirability of throwing away the first version or two of the object design before we get one that really works, we can write code that is pretty robust and extensible. If we are allowed to take the time to write code thoughtfully, it will be better code. However, I certainly don't want to encourage more mind-numbing walkthroughs and code inspections—they just waste my time and yours.

One discipline that has gotten a bit of attention lately is extreme programming. With a name like that, you think of in-line skates, elbow pads, and parachutes. But it is incredibly simple-minded at heart. Every time you add a feature to a program, you write a test case to prove it works. This sounds great, but coming up with these test cases is not as simple as you'd think. You have to warp your mind in new ways to make sure you're testing the right thing.

How about creating objects that can test themselves? Now there's an extreme idea, and not one that you dismiss out of hand. If we design a system as a set of objects, surely we can design objects that test the system or themselves. When we subclass the objects, we need to subclass the tests, but that's easier than writing them again.

Building Objects

If you are determined to design better software using good OO techniques, here are a few suggestions to remind you of how you can do it. Many of them are suggestions by Riel (see Resources).

- Define a set of classes that are significant. Each class should have a real role to play, and should not just be a broken-off piece of some monolithic design.
- Classes should hide their data. You shouldn't ever need to know much about what is inside a class.
- Data and the actions on that data should always be in the same class.
- Classes should not know they have descendants. Otherwise, why write descendants at all?
- Beware of the "god class." A single class should never control too much of the program. This can easily become a problem when writing Mediator patterns.
- Classes should not be actions. If your class hierarchy has classes whose names are verbs (like "Print"), try again.
- Classes should not be single-minded. Maybe it is an action disguised as a class. Try again.
- Classes should be significant. Why does a class exist?

Writing Quality into Your Software

Do managers think that allocating time for testing during the heat of deadline-driven development is a waste of time? Do programmers think so? How about you? And if you do, does your software suck?

If I haven't offended you yet, it wasn't for lack of trying. What do you think explains the sorry state of software quality? And how do you solve the problem in your work, or in general? Let me know. ■

James W. Cooper is a computer science researcher and the author of 13 books. His latest book, *Java Design Patterns: A Tutorial*, was published by Addison Wesley Longman in January 2000.

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Client-Server Vs. Web Development

by Adam Kolawa

Due to the enthusiastic response of our readers, we have decided to continue our series of columns about software development by taking a look at some of the current trends in the industry. The Web has changed software development forever, and it doesn't take a prophet to know that this trend will continue. As more and more sophisticated applications move online, the Web is no longer just a place for simple, static Web sites. As such, it's time for software developers to take a serious look at the issues surrounding Web development.

The software industry has always been fond of pitting one development technique against another. Nowadays, one of the hottest debates is between supporters of client-server development and Web development. Web proponents sometimes claim client-server is dead; client-server users see glaring weaknesses in the Web paradigm. To make a decision on which to use, it is important to understand the critical differences between the two approaches.

When the industry first began to look at dynamic Web development, they saw the HTML output pages and assumed Web development was limited to providing changing text to viewers. Before long, however, developers realized the full potential of the technology; they could write applications that interacted with databases at the back end, and use a Web browser as a standard GUI at the front end. The problem of teaching people to use a GUI would disappear because any computer owner--and, therefore, any potential software purchaser--knows how to use a Web browser.

It appeared at this point that client-server was in trouble. After all, every client-server application has a learning curve, and often a very steep one, because people must learn to use a proprietary client before they can put the application to full use. When companies realized they could deliver applications with a standard GUI that everyone already knew how to use, they flocked to the Web. Web-based applications offer additional benefits: they give developers the ability to update software in one place--the server--rather than mailing out updates, they streamline maintenance, and they increase the portability of applications. But in our next column, we'll explain why Web development isn't a "silver bullet" solution, and why client-server still has a valuable place in software development

Adam Kolawa, Ph.D., is Chairman and CEO of ParaSoft. You can reach him at ak@parasoft.com

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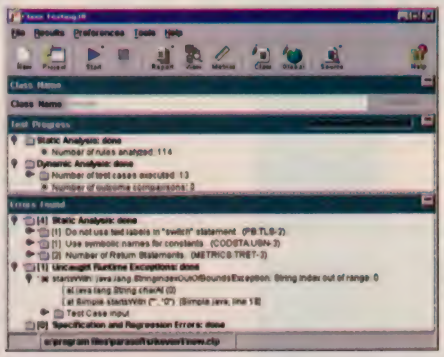

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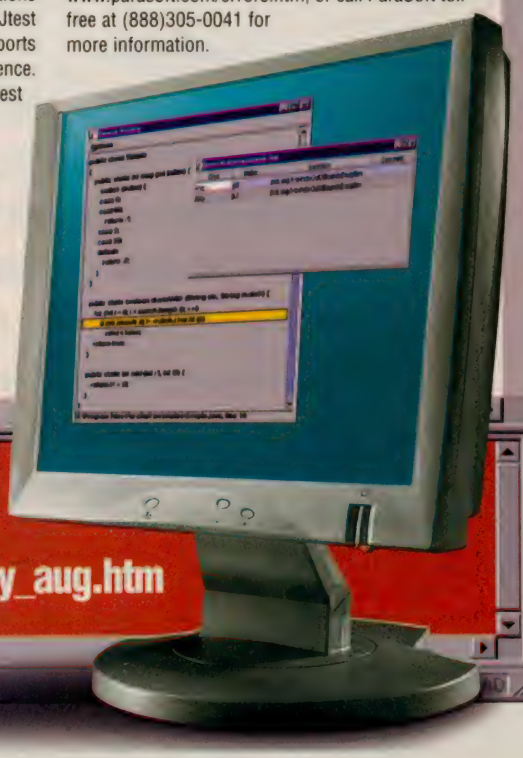

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Java in Transition

Transition between two images using this fun component

BY CLAUDE DUGUAY

This month's installment, JTransition, is a fun component based on visual transitions between two images. This is the kind of thing you're used to seeing on television. You can perform an endless number of tricks to transition between images. Our primary focus will be on a Transition interface and a few example implementations. Microsoft's PowerPoint supports this kind of transition capability between slides, as do other presentation applications. You can use this feature any time you have two images to transition between.

One of the obvious assumptions is that you have two images of the same size, though our code will deal with divergent sizes well enough. Figure 1 shows an overlay transition midway through its sequence. The smaller image at the lower left is scaled because we've selected a Size-based transition. It is coming in, rather than going out, because we chose that direction in the bottom left pulldown menu. Finally, the image is coming in toward the North and East. The JTransitionTest example allows you to select the vertical and horizontal direction, whether the image is coming in or going out, and whether the transition clips the incoming image, moves in or out, or whether it scales the size on the way in or out.

Figure 2 shows the classes we'll implement in this article. We use a common Transition interface to make it possible to plug in any transition we can invent using the same basic model. The TransitionConstants are kept separate because they may not apply to all Transition implementations, though they do apply to the ones in this article. We use an AbstractTransition class to implement some of the common behaviors shared by the other implementations. Each of our example transitions extends the OverlayTransition class. This is not a limitation of the interface, but rather of the time I was able to spend coming up with examples.

The Transition interface is very simple, allowing us to set a source and target image and call a simple transition method to actually execute the effect. The component argument is required so that we can get a reference to the Graphics object.

```
public interface Transition
{
   public void setSourceImage(
     Image source);
   public void setTargetImage(
     Image target);
   public void transition(Component comp);
}
```

Figure 1 OverlayTransition at Work Here we see an overlay transition midway through its sequence. The JTransitionTest example allows you to select the vertical and horizontal direction, whether the image is coming in or going out, and whether the transition clips the incoming image, moves in or out, or whether it scales the size on the way in or out.

Listing 1 shows the source code for the AbstractTransition class. Pretty much any Transition we're likely to implement has to store a reference to the source and target images, so we handle this in a common class. Another common operation is to pause for a specified number of milliseconds. We use this method to pause between frames so that the transition is not displayed too quickly. A final utility method called invertDirection() returns the opposite direction for NORTH, SOUTH, EAST, and WEST, returning the same value if the input is any other integer.

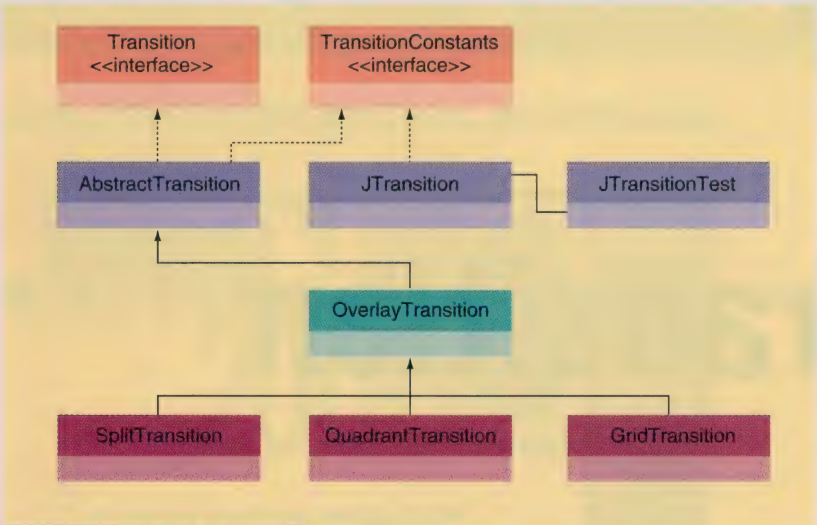

Figure 2 JTransition Classes Here are the classes we'll implement in this article. We use a common Transition interface to make it possible to plug in any transition we can invent using the same basic model.

With our AbstractTransition complete, we can implement a set of overlapping transitions to demonstrate how you can apply the Transition interface in practice. OverlapTransition expects a number of values in the constructor, aside from the source and target images. The type determines whether we are dealing with a MOVE, CLIP, or SIZE transition. The vert and horz values represent whether we are moving from the NORTH or SOUTH and/or EAST or WEST, respectively. The inout value is either IN or OUT, indicating whether the image is moving inward from the outside or vice versa. We can also define the number of steps we'd like to see (this is the number of frames), as well as the interval (in milliseconds) between frames.

Listing 2 shows the OverlapTransition class. The transition() method steps through each frame by calling the drawFrames() method. The drawFrames() method, in turn, calls the drawCell() method for each rectangular cell on display. You'll notice that we don't do standard paint() or paintComponent() calls to do this work. Instead, we draw directly into the graphic context because we want to see the display take place immediately. If we didn't do this, basic Java, Swing, or OS paint optimizations might get in the way and cause transitions to skip frames or lose fluidity.

If you take a close look at the drawCell() method, you'll see that each cell drawing depends on the rectangular area the cell encompasses, as well as the type (MOVE, CLIP, or SIZE) setting and the vertical and horizontal direction indicators. At the end of all the numerical adjustments, we end up with a drawImage() call that draws a portion of the cell image or a scaled version. The destination image uses variables prefixed by the "d" character, and the source image has an "s" prefix to make the code more readable.

The drawCells() method is shared by each of the OverlapTransition subclasses. Because the subclasses involve nothing more than a few alternating directional flips, only the drawFrames() method needs to be implemented. The SplitTransition class allows you to have vertical or horizontal transitions moving in opposing directions. A typical transition might look like a curtain opening or closing. The QuadrantTransition further mirrors the second axis, so that the result looks more like a box opening or closing. Figure 3 shows the second image moving out toward the corners, leaving the target image behind. The final Transition implementation I've developed is called GridTransition. It divides the image into an arbitrary number of cells, defined as a given number of vertical and horizontal divisions. The

You can add an endless number of possible transitions to this interface

GridTransition is used to demonstrate the vertical and horizontal bar options as well, by using a single division on the least significant axis. Both the 5×5 and 20×20 examples in the test class also use it.

Of course, none of this is useful if we don't have a good framework for presenting transitions. That's where the JTransition component comes into play. You can see this listing online at www.java-pro.com. It is designed to accept a source and target image and an instance of the Transition interface. Once you have an instance, you can set or get the transition or call the transition() method to execute the visual effect. To make it easy to transition back to the first image without undue complexity, we implement a flipSourceAndTarget() method. You can also control which image is being displayed by calling the showSource() and showTarget() methods.

When you download the online code, you'll find a JTransitionTest class. It's what you see in the screen captures. It works by assigning

Continued on page 56

Listing 1 AbstractTransition Class This is the source code for the AbstractTransition class. Pretty much any Transition we're likely to implement has to store a reference to the source and target images, so we handle this in a common class.

```
import java.awt.*;

public abstract class AbstractTransition
  implements Transition, TransitionConstants
{
  protected Image source, target;

  public AbstractTransition(Image source, Image target)
  {
    this.source = source;
    this.target = target;
  }

  public void pause(int pause)
  {
    try
    {
      Thread.sleep(pause);
    }
    catch (InterruptedException e) {}
  }

  public int invertDirection(int dir)
  {
    if (dir == NORTH) return SOUTH;
    if (dir == SOUTH) return NORTH;
    if (dir == EAST) return WEST;
    if (dir == WEST) return EAST;
    return dir;
  }

  public void setSourceImage(Image source)
  {
    this.source = source;
  }

  public void setTargetImage(Image target)
  {
    this.target = target;
  }
}
```

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Listing 2 OverlapTransition Class Here is the OverlapTransition class. The transition() method steps through each frame by calling the drawFrames() method. The drawFrames() method, in turn, calls the drawCell() method for each rectangular cell on display.

```
import java.awt.*;
import java.awt.image.*;
import javax.swing.*;

public class OverlapTransition extends AbstractTransition
{
  protected int type, vert, horz, inout, steps, interval;
  protected BufferedImage[] frames;

  public OverlapTransition(Image source, Image target,
    int type, int vert, int horz, int inout, int steps,
    int interval)
  {
    super(source, target);
    this.type = type;
    this.vert = vert;
    this.horz = horz;
    this.inout = inout;
    this.steps = steps;
    this.interval = interval;
  }

  public void transition(Component comp)
  {
    if (horz == NONE && vert == NONE)
    {
      Graphics g = comp.getGraphics();
      g.drawImage(target, 0, 0, comp);
      g.dispose();
      return;
    }
    int w = comp.getSize().width;
    int h = comp.getSize().height;
    drawFrames(comp, 0, 0, w, h);
  }

  protected void drawFrames(Component comp,
    int x, int y, int w, int h)
  {
    Graphics gc = comp.getGraphics();
    BufferedImage frame = new BufferedImage(
      comp.getSize().width, comp.getSize().height,
      BufferedImage.TYPE_INT_RGB);
    Graphics g = frame.getGraphics();
    for (double i = 1; i <= steps; i++)
    {
      g.drawImage(inout == OUT ? target : source, 0, 0,
        comp);
      drawCell(comp, g, i, vert, horz, x, y, w, h);
      gc.drawImage(frame, 0, 0, comp);
      pause(interval);
    }
    gc.dispose();
  }

  protected void drawCell(Component comp, Graphics g,
    double i, int vert, int horz, int x, int y, int w,
    int h)
  {
    double xUnit = (double)w / (double)steps;
    double yUnit = (double)h / (double)steps;

    int xp = 0;
    if (inout == IN) xp = (int)(xUnit * i);
    if (inout == OUT) xp = w - (int)(xUnit * i);

    int yp = 0;
    if (inout == IN) yp = (int)(yUnit * i);
    if (inout == OUT) yp = h - (int)(yUnit * i);

    Image image = inout == OUT ? source : target;
    int dx1 = x, dx2 = x + w;
    int dy1 = y, dy2 = y + h;
    int sx1 = x, sx2 = x + w;
    int sy1 = y, sy2 = y + h;

    if (horz == EAST)
    {
      if (type == MOVE)
      {
        dx1 = x; dx2 = x + xp;
        sx1 = x + w - xp; sx2 = x + w;
      }
      if (type == CLIP)
      {
        dx1 = x; dx2 = x + xp;
        sx1 = x; sx2 = x + xp;
      }
      if (type == SIZE)
      {
        dx1 = x; dx2 = x + xp;
        sx1 = x; sx2 = x + w;
      }
    }
    if (horz == WEST)
    {
      if (type == MOVE)
      {
        dx1 = x + w - xp; dx2 = x + w;
        sx1 = x; sx2 = x + xp;
      }
      if (type == CLIP)
      {
        dx1 = x + w - xp; dx2 = x + w;
        sx1 = x + w - xp; sx2 = x + w;
      }
      if (type == SIZE)
      {
        dx1 = x + w - xp; dx2 = x + w;
        sx1 = x; sx2 = x + w;
      }
    }
    if (vert == SOUTH)
    {
      if (type == MOVE)
      {
        dy1 = y; dy2 = y + yp;
        sy1 = y + h - yp; sy2 = y + h;
      }
      if (type == CLIP)
      {
        dy1 = y; dy2 = y + yp;
        sy1 = y; sy2 = y + yp;
      }
      if (type == SIZE)
      {
        dy1 = y; dy2 = y + yp;
        sy1 = y; sy2 = y + h;
      }
    }
    if (vert == NORTH)
    {
      if (type == MOVE)
      {
        dy1 = y + h - yp; dy2 = y + h;
        sy1 = y; sy2 = y + yp;
      }
      if (type == CLIP)
      {
        dy1 = y + h - yp; dy2 = y + h;
        sy1 = y + h - yp; sy2 = y + h;
      }
      if (type == SIZE)
      {
        dy1 = y + h - yp; dy2 = y + h;
        sy1 = y; sy2 = y + h;
      }
    }
    g.drawImage(image, dx1, dy1, dx2, dy2, sx1,
      sy1, sx2, sy2, comp);
  }

}
```

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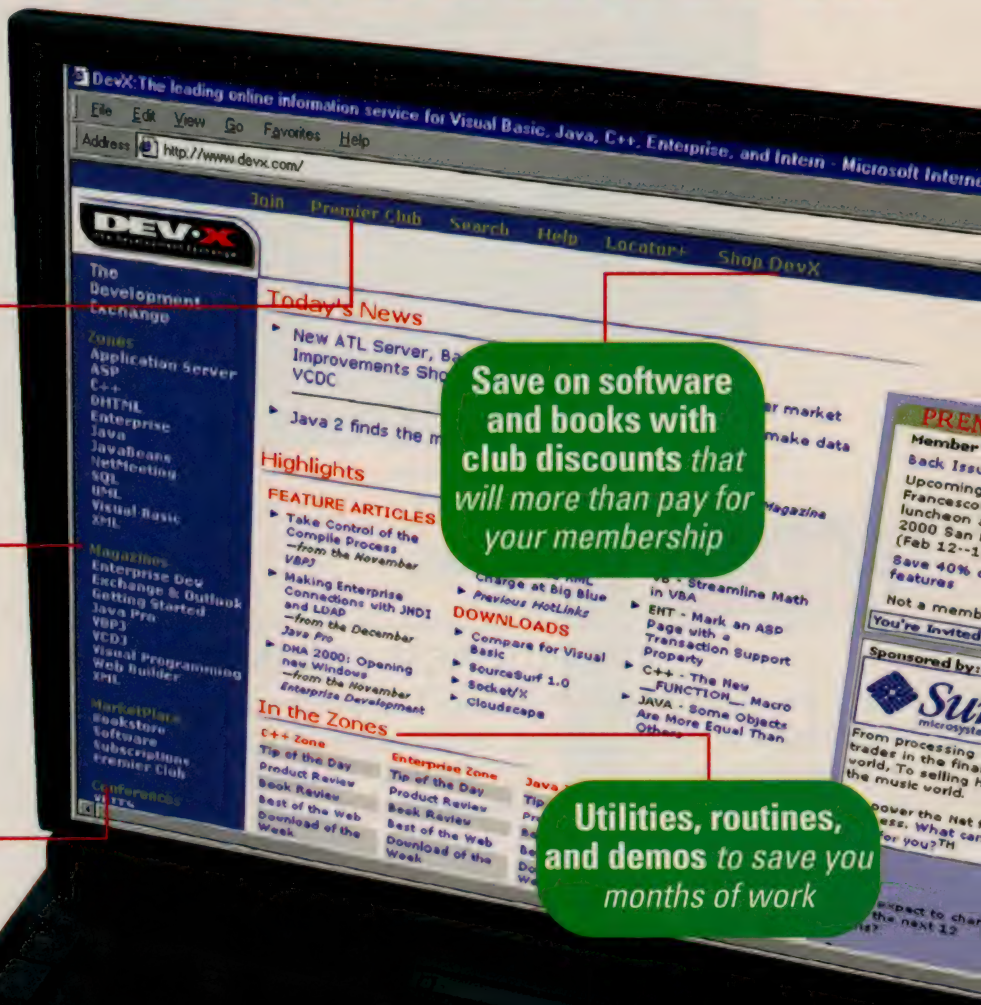
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Transition instances to a multi-dimensional array and using the pulldown menu indexes to select the Transition to use. When you press the Show button, the transition executes. When you first run it, the vertical and horizontal selectors are set to NONE, so you need to flip at least one of those to see anything useful. In any case, I think you'll find it pretty entertaining to play with the various settings just to see what each transition can look like.

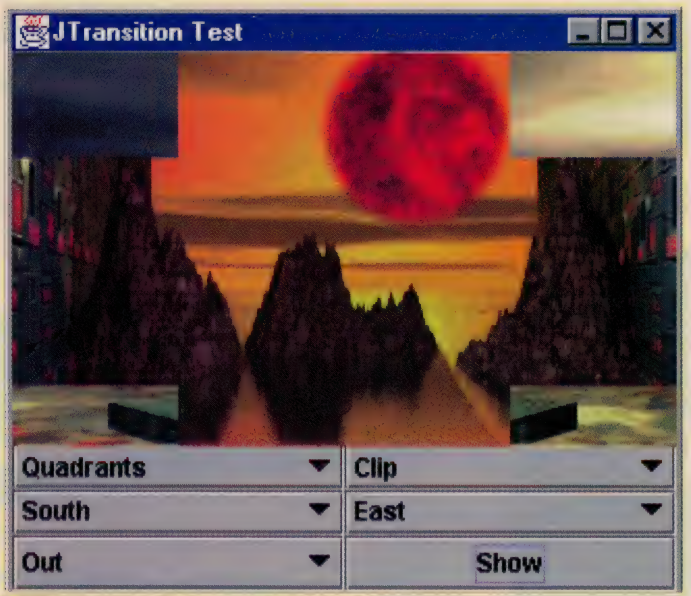

Figure 3 QuadrantTransition at Work The SplitTransition class allows you to have vertical or horizontal transitions moving in opposing directions. Here we see the second image moving out toward the corners, leaving the target image behind.

You can add an endless number of possible transitions to this interface. Obvious choices include a growing or shrinking circle/oval transition; a rippling transition; a lens effect; random pixelation/replacement; rolling corner/page turns; puzzle pieces; three dimensional rotations; cube turns; spherical wraps; etc. If you work with presentation software, you'll need something like this along the way. You can use this component and the Transition interface to implement Easter eggs, fancy "about" dialog windows, special visual effects, or whatever you see fit to present to your users. ■

Claude Duguay is vice president of Engineering at ActiveIndexing Corp. He has developed software for more than 20 years. He is passionate about Java, reads about it incessantly, and writes about it as often as possible. You can reach him at claude@activeindexing.com.

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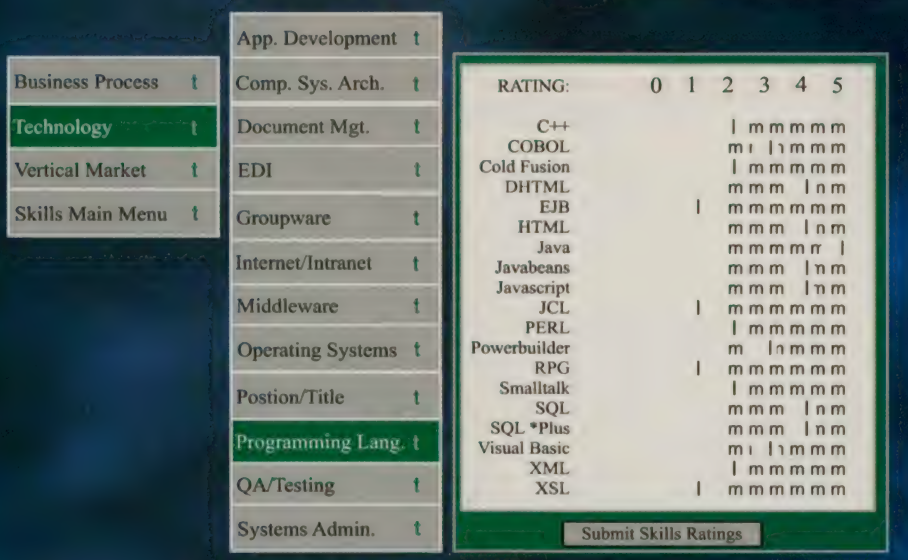

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Java To Go

A Java Epoc

A 32-bit multithreaded handheld OS, built on a client/server paradigm that runs Java applets and applications? Try EPOC

BY RICK GREHAN

Most of my recent columns have focused on Java development for the Palm handheld devices. As popular as Palm systems are, I would nevertheless like to turn your attention to Java development on other handheld devices. In particular, I would like to spend the next three or four columns exploring what Java has to offer for the Psion/Symbian handheld devices (and what they have to offer to Java).

The operating system in use in those handhelds is Symbian's EPOC OS. Though engineered specifically as an OS for small systems, EPOC's capabilities are remarkably sophisticated.

What makes EPOC interesting for Java developers is the fact that Symbian has recently released a Java SDK for the EPOC operating system. It is free for downloading at www.symbiandevnet.com/downloads/downloads.html. (You'll need to register with the EPOC Developer Network—which is free of charge.) Even if you're unlucky enough not to own an EPOC-powered device, don't fret. You can still begin exploring Java development on the EPOC OS. Included in the Java SDK is the EPOC Emulator, which runs on the Windows 9x or NT operating systems. The EPOC Emulator, coupled with the EPOC Java SDK, provides you with everything you need to build Java applications and execute them on an EPOC environment.

Inside EPOC

EPOC is a 32-bit operating system for use in mobile and handheld devices that use as their mass storage a combination of ROM, Flash, and RAM memory. Currently, EPOC runs on a variety of Psion handheld devices, including the Psion REVO, Series 7, Series 5 and 5mx, as well as the Ericsson MC218 (actually OEM-manufactured by Psion). EPOC is also the OS that powers the Ericsson R380 smartphone.

At the time of this writing, the version of the EPOC OS available in the EPOC Java SDK is version 5. (By saying that the OS is "available," I don't mean to imply that you can download the EPOC OS, burn a set of ROMs, and put it into your favorite handheld. The EPOC runtime that you download in the form of the emulator executes atop the Win32 API, and requires a Windows foundation to run.) This version of EPOC features a Java runtime environment that is based on Sun's JDK version 1.1.4 (Java AWT is supported). EPOC 5 also provides a Web browser, so you can run applets as well as applications.

Though I'm specifically interested in EPOC as a Java platform, I would be remiss in not mentioning that Symbian also provides downloadable SDKs for two other languages: the Psion Organizer Programming Lanuage (OPL) and C++. OPL is a procedural language that bears some resemblance to BASIC. Its advantage is its simplicity and small code footprint (OPL is translated into an intermediate code and executed by an OPL runtime) as well as the fact that the OPL SDK is complete—it requires no additional tools for development. By contrast, the C++ SDK requires Microsoft's Visual C++ (version 4.x or 5.0) for development on the EPOC Emulator, as well as the GNU compiler for compilation into code for execution on the actual target device. (The GNU compiler is included with EPOC C++ because target EPOC devices currently use ARM processors.)

If you're drawn to serious Java development on EPOC devices, you'll need to download the C++ SDK. EPOC's Java implementation supports a native interface, and native methods are the gateway into EPOC-specific APIs. (The C++ SDK also includes more in-depth information on the EPOC operating system. So, it's worth the download if you want to dig further into the OS capabilities and architecture.)

Seen from a high altitude, EPOC is more than an operating system. It includes an OS kernel, a collection of user libraries (of interest to C++ programmers), and a GUI framework. EPOC's kernel uses a timer–interrupt-driven round-robin scheduler to provide preemptive multithreading. (The timer interrupts that are the scheduler's heartbeat differ in frequency depending on whether EPOC is running on the handheld or in the emulator, so multithreaded application behavior may vary slightly between execution on the emulator and execution on a target device.)

Rather than being structured as a monolithic OS, EPOC divides OS functions among servers. Indeed, much of the interaction between applications and the EPOC OS takes place in true, client/server fashion. This has the benefit of consolidating all of

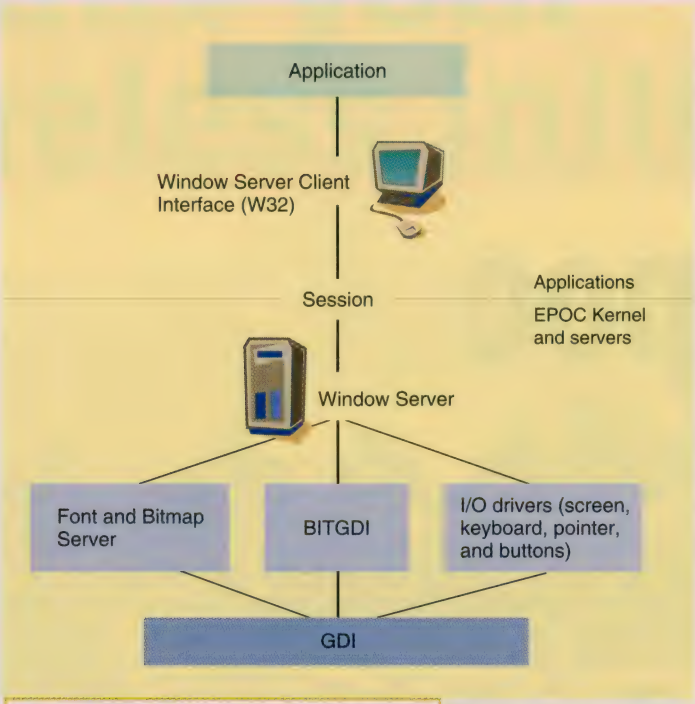

Figure 1 EPOC's Client/Server Architecture This simplified view of the EPOC graphics system illustrates two important features of the EPOC OS. One is its highly componentized nature; subsystems are decoupled as much as possible, making for easy porting to new targets. The other feature is the client/server architecture within the OS itself. Applications (clients) establish a session with the Window Server in order to "transact business" with the graphics system. Other important components of the system are the BITGDI (which handles the actual rendering of bitmaps to the screen), the font and bitmap server (also called FBSERV, which manages font and bitmap resources), and the various I/O device drivers. The GDI component is simultaneously the foundation and bonding glue for the system.

the functions associated with a particular capability into a single, shared entity (a server). (See Figure 1.)

For example, applications in EPOC do not write directly to the display. Rather, they write to a client interface (referred to as W32), which is a communication layer that talks to the Window Server. The Window Server executes in a high-priority thread (only the kernel thread is higher). An application (the client) actually establishes a session with the Window Server; the Window Server handles the access that the application has to the system's screen, keyboard, and pointer device. (This is only of passing interest if you want to keep Java development in the realm of the AWT implementation. In which case, you may remain blissfully unaware of the Window Server. But many of the downloadable applications on the Symbain Web site make heavy use of the Java native interface to provide a more direct access between Java application and the Window Server.)

Much of the interaction between applications and the EPOC OS takes place in true, client/server fashion

Similarly, the EPOC OS filesystem services are handled by the F32 file server component, which, though considered separate from the kernel, nevertheless works closely with the kernel to provide support for the various removable and fixed disk emulation systems. F32 can handle both fixed and removable file media, as well as RAM disks. Filesystem volumes are formatted using a VFAT-compatible file allocation system (which permits filenames up to 256 characters long), and there can be up to 26 "disk drives" on a system. (Each "disk" is associated with a single letter, and specific letters are usually associated with a particular media type.)

EPOC Engines

EPOC's "engine" paradigm is yet another means of consolidating code. In brief, an engine is a kind of mini-application that provides access to a particular kind of data. So, a developer might create a datafile structure that represents an electronic circuit diagram. On EPOC, that developer would next create an "electronic circuit" engine, and that engine would be the means by which any application would be able to read, write, and otherwise manipulate "circuit" files.

What's important here is that EPOC is equipped with a number of built-in engines into which applications can call. These engines include:

- **Data manipulation:** This consists of an amazingly powerful relational database API that includes SQL access, transaction, encryption, indexes, and even rollbacks. And, since this is designed for a small-footprint system, this engine also supports space reclamation (database compaction).

- **Application architecture:** This component of the engine handles the association of a particular file with its appropriate application (such as, which application opens a file when you click on that file's icon). In the case of native files, EPOC relies on a system of UIDs (universal identifiers) for this purpose. Each application is given a UID; a file created by the application carries its creator's UID, so that subsequent opening of that file launches the correct application. Foreign files (copied onto the handheld device from elsewhere) are identified either by their file extension or their MIME type.

- **Resource files and affiliated services:** Services in this engine provide the means by which an application's executable code is kept separate from that application's resources. In this instance, examples of resources would be strings that the application displays—such as the title to a button or a textbox. Keeping resources separate simplifies the conversion of an application written for English-speaking users into one written for, say, Spanish-speaking users (only the resources need be changed; the application code is untouched). Other utilities in this area of EPOC handle such things as sound recording and playback and DTMF dialing.

- **The standard library:** Of interest to C programmers, EPOC's standard library provides a POSIX-like layer atop the EPOC APIs.

- **Text handling:** The text-handling component consists of a collection of APIs that provides such capabilities as spell-checking (using an algorithm that provides a compact English dictionary of about 100,000 words), conversion among different character sets, and services for manipulating arbitrary text that handle paragraph formatting, text headers and footers, embedded graphics, and more.

EPOC Graphics

As with most of EPOC, its graphics system is a collection of cooperating components. The bedrock of the graphics system is the GDI (graphics driver interface), which includes drivers for user I/O de-

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Figure 2 EPOC Emulator Running Java The EPOC Emulator (shown here using the fascia of a handheld device) is running the familiar MoleculeViewer applet in EPOC 5's new browser. The EPOC Emulator executes a fully functioning EPOC-based handheld device. Everything works: keyboard, mouse (which substitutes for the stylus), even all the built-in applications. In fact, you can even "connect" the emulator's networking system to your existing Windows networking system and use the emulator's e-mail and Web services just as one would on a target device.

vices—screen, pointer, buttons, and so on. (Note that some EPOC devices are armed with a row of buttons that are treated as separate from keyboard keys.) The GDI also includes software for handling fonts, colors, zooming, and so on.

As mentioned previously, EPOC's Window Server is the component through which, ultimately, passes all graphics output. It includes the functions for line, box, and poly-line drawing, as well as area clearing, filling, inverting, and so on. The Window Server itself launches (and interoperates with) the font and bitmap server (a single server) that manages fonts and off-screen bitmaps. Actual rendering on screen is handled by yet another component, the BITGDI, whose job it is to deliver bitmaps onto the screen.

EPOC's GUI system is EIKON (which is also an application framework). It is important to note that EIKON was developed from the start as a GUI system for handheld devices; it is not a PC GUI system that has been trimmed down to fit the confines of handheld systems. You can detect EIKON's handheld origins if you study its behavior. For example, a pen (or stylus) input device doesn't work precisely like a mouse. There is no way to "right click" a stylus; nor can a stylus be used to "hover" over on-screen entities.

Consequently, EIKON uses a "select-and-open" paradigm. Touching an unselected on-screen item (an application icon, for example) selects the icon. Touching a selected item (regardless of how long the item has been selected) opens that item.

Symbian's documentation for EPOC describes the graphics functions of the OS as being "broadly similar" to those implemented by Windows. This similarity certainly eased the implementation of the EPOC Windows Emulator, not only in the area of on-screen graphics generation, but in the implementation of printer drivers as well. (EPOC allows a handheld device, connected to a PC, to "print through" the PC to a printer connected to the PC.)

The EPOC Emulator

The EPOC Emulator runs on Windows 9x and Windows NT. It is provided as part of the language SDKs (mentioned previously), and allows for a development process that begins with coding and debugging on the desktop before moving the application to the target device for final shakedown. Java development with the EPOC Emulator enjoys an additional twist. Since the Java environment on EPOC is compatible with the JDK 1.1.4, and includes an AWT, initial coding and testing can take place in a standard Java VM running on Windows. Once the larger bugs have been killed, you can move your application into the emulator, test there (the Java VM that runs in the emulator supports debugging using jdb), then transfer to the target. In a sense, you're taking a series of steps that lead from the resource-rich desktop to the resource-constrained target.

Of course, the EPOC OS is not the same as the Windows OS, so there are peculiarities that you have to be aware of as you build your application. Some are obvious; for example, the screen size of the target is going to be smaller and of different dimension than a desktop screen. Other differences are less obvious; for example, there are no environment variables in the EPOC OS. Consequently, you have to be aware of the actions taken by the Java VM to locate classfiles. On the handheld target, the virtual machine searches for classfiles by scanning removable flash drives first, RAM drives next, and finally any ROM drives. (Precisely which sort of memory a particular drive has can be ascertained from the drive letter. This is spelled out in the SDK's documentation, and I won't go into it here.)

Nevertheless, the emulator's Java support is (based on my first experiments) remarkably good. Figure 2 shows a screen capture from my Windows NT laptop system running the EPOC Emulator's browser. I have launched the well-known MoleculeViewer applet in the browser. The mouse takes the place of the stylus, and (though I can't show this in the magazine) the molecule rotates with surprising response. (The Java SDK's EPOC Emulator comes preloaded with a variety of familiar Java applet examples.)

EPOC Making

From my explorations thus far, I find EPOC to be an exceptional operating system and collection of application utilities that will give competing OSs in the handheld market a run for their money. For Java developers, the availability of the EPOC Windows Emulator as part of the EPOC Java SDK provides a free-for-the-downloading testing ground.

EPOC Emulator provides more than just a bare-bones environment; all the functioning applications are provided: the Agenda organizer, the word processor, the notecard-style database, and more. So, not only can you create and run "pure" Java applets and applications that are unaware that they are executing on an EPOC system, you can create Java applications that read and write application data (the agenda database, for example) and test the results against the actual application.

Next month, I'll walk through the installation steps of the EPOC Emulator and the Java SDK. I'll also write a simple Java application and go over some nuances that you'll have to be aware of while you're writing Java programs for handheld devices as well as for the EPOC OS—regardless of the target device.

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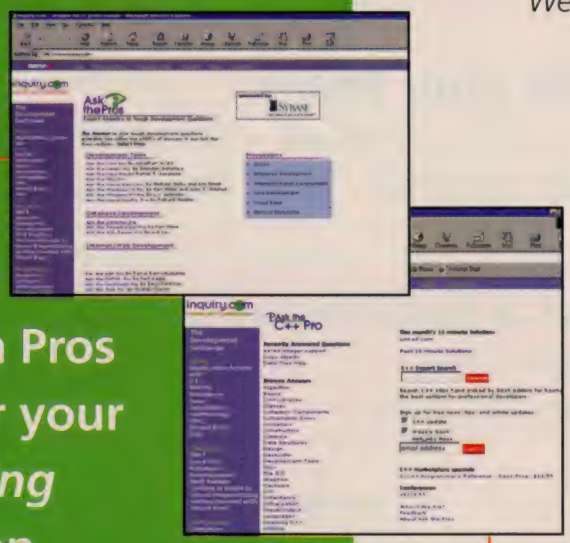

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times. In fact, that's what AltaVista did when it first started—it used a cluster of Alpha servers to deliver search results faster.

Java provides several options for writing parallel programs for clusters, including hand-crafted socket communication, RMI, and Jini/JavaSpaces. RMI is probably the easiest to start with. A very common way of structuring a parallel program is the master/slave model. The master process spawns many slave processes that perform the computation, possibly communicating with each other, and return the results back to the master. The main difficulty with this model is how to spawn the slaves and coordinate communication between them. RMI does not solve the problem of launching the slave processes. Most parallel programming APIs still use remote command–execution commands such as rsh or ssh to spawn processes on other processors. RMI does make it easy to coordinate communication through its naming service and remote method invocation support.

To give you a flavor of parallel programming with RMI, I have constructed a very basic example program (see Listing 1) that computes the average value of a sequence of random numbers using a random number generation support class, described in the answer to one of this month's questions. The program consists of a master object, called MeanCollector, which collects the mean values computed by its RandomMean slaves. The timing code in MeanCollector is not accurate since the master is started first and each slave is started manually thereafter, but it is close enough for getting a rough estimate of execution time. This is an example of an embarrassingly parallel application, where there is no communication between the slaves. The implementations of the MeanCollector and RandomMean interfaces, MeanCollectorImpl and RandomMeanImpl, also contain the main program for using each, for the sake of simplicity in the example. MeanCollectorImpl stores the range of random numbers to be generated (1–100 in the example), and the number of iterations each slave should use in computing the average (50 million divided by the number of slaves in the example).

I ran this on one, two, and four processors, taking 110, 56, and 29 seconds, respectively, demonstrating roughly linear scaling. To achieve linear scaling, the computing nodes should be homogeneous (the same architecture and comparable processing power). Otherwise, you need to partition the work allocated to each node in proportion to its processing power. The example doles out the same amount of work (number of iterations) to each processor. I was happy to discover that the computed average was very close to 50.5, which is what you would expect from a sufficiently random number generator. If you are interested in writing parallel programs in Java, there are more suitable approaches than RMI. You can find more information at the Java

Java provides several options for writing parallel programs for clusters

Listing 1 Using RMI This basic example program shows parallel computing using RMI. It computes the average value of a sequence of random numbers using a random number generation support class. The program consists of a master object, called MeanCollector, which collects the mean values computed by its RandomMean slaves.

```
import java.rmi.*;

public interface MeanCollector extends Remote {

  public int getIterations() throws RemoteException;

  public int getMaxRange() throws RemoteException;

  public int getMinRange() throws RemoteException;

  public void collectMean(double mean) throws
    RemoteException;
}

import java.rmi.*;

public interface RandomMean extends Remote {
  public void computeMean(MeanCollector collector) throws
    RemoteException;
}

import java.net.*;
import java.rmi.*;
import java.rmi.server.*;

public class MeanCollectorImpl extends UnicastRemoteObject
  implements MeanCollector
{
  private int __maxCollections, __collections;
  private int __minRange, __maxRange, __iterations;
  private double __total;
  private int[] __monitor;

  public MeanCollectorImpl() throws RemoteException {
    setMaxCollectionCount(0);
    __monitor = new int[0];
  }

  public void setMaxCollectionCount(int count) {
    __maxCollections = count;
    __collections    = 0;
    __total          = 0.0;
  }

  public void setMeanParameters(
    int minRange, int maxRange, int iterations) {
    __iterations = iterations;
    __minRange = minRange;
    __maxRange = maxRange;
  }

  public int getIterations() throws RemoteException {
    return __iterations;
  }

  public int getMaxRange() throws RemoteException {
    return __maxRange;
  }

  public int getMinRange() throws RemoteException {
    return __minRange;
  }

  public void collectMean(double mean) throws
    RemoteException {
    synchronized (__monitor) {
      __total+=mean;
      ++__collections;
      __monitor.notify();
    }
  }

  public double computeMean() {
    synchronized(__monitor) {
      while(__collections < __maxCollections) {
        try {
```

Continued on page 66.

Grande Project (www.javagrande.org) and the Java MPI home page (perun.hscs.wmin.ac.uk/CSPE/software.html).

Q When I use InetAddress.getAllByName(String host) on my workstation, I get two IP addresses. One is for the LAN connection and the other is for the dialup connection. I need to get the dialup connection's IP address because the LAN's IP address is only known by the local network. Is there a way to determine which IP is which? Are they ordered?

A Unfortunately, the order in which the IP addresses are returned is platform dependent. You cannot rely on the primary network interface being listed first all of the time. However, when writing network client or server applications, if you do not bind to a specific interface, your application will work across both interfaces. If you have a client application that is already connected, you can always determine which interface it is on by calling Socket.getLocalAddress(). However, if you really need to know which IP ad-

Continued from page 65.

```
          __monitor.wait();
        } catch(InterruptedException e) {
        }
      }
    }
    return (__total/(double)__collections);
  }


  public static void main(String args[]) {
    MeanCollectorImpl collector = null;
    int numSlaves;

    if(args.length < 1) {
      System.err.println("Usage: master numslaves");
      return;
    }

    try {
      InetAddress address;
      String url, hostname;
      double mean;
      long time;

      numSlaves = Integer.parseInt(args[0]);

      address = InetAddress.getLocalHost();
      hostname = address.getHostName();

      collector = new MeanCollectorImpl();
      collector.setMaxCollectionCount(numSlaves);
      collector.setMeanParameters(
        1, 100, 50000000/numSlaves);

      url = "//" + hostname + "/MeanCollector";
      Naming.rebind(url, collector);
      System.out.println(
        "Bound MeanCollector in registry: " + url);

      time = System.currentTimeMillis();

      mean = collector.computeMean();

      time = System.currentTimeMillis() - time;

      System.out.println("Mean: " + mean);
      System.out.println("Time Elapsed (seconds): " +
        (double)time/1000.0);
    } catch(Exception e) {
      e.printStackTrace();
      return;
    } finally {
      if(collector != null) {
        try {
          UnicastRemoteObject.unexportObject(
            collector, true);
        } catch(NoSuchObjectException e) {
        }
      }
    }
  }

}

import java.net.*;
import java.rmi.*;
import java.rmi.server.*;

public class RandomMeanImpl extends UnicastRemoteObject
  implements RandomMean
{
  private RandomIntGenerator __generator;
  private MeanCollector __collector;

  public RandomMeanImpl() throws RemoteException {
    __generator = new RandomIntGenerator();
  }

  public void computeMean(MeanCollector collector)
    throws RemoteException
  {
    long total = 0L;
    int iterations;

    __collector = collector;
    iterations = collector.getIterations();
    __generator.setRange(collector.getMinRange(),
      collector.getMaxRange());

    for(int i = 0; i < iterations; ++i)
      total+=__generator.nextInt();

    __collector.collectMean((double)total/
(double)iterations);
  }


  public static void main(String args[]) {
    String url, hostname;
    RandomMeanImpl random = null;

    if(args.length < 1) {
      System.err.println("Usage: slave masterhost");
      return;
    }

    hostname = args[0];

    try {
      MeanCollector collector;

      random = new RandomMeanImpl();

      //Register and wait for collector to ask us to
      //compute
      url = "//" + hostname + "/MeanCollector";
      random.computeMean((MeanCollector)Naming.lookup(url));
    } catch(Exception e) {
      return;
    } finally {
      if(random != null) {
        try {
          UnicastRemoteObject.unexportObject(random, true);
        } catch(NoSuchObjectException e) {
        }
      }
    }
  }
}
```

dress corresponds to which interface, you can always write some native code or use Runtime.exec() to execute a local utility such as ifconfig (Unix) and parse the output.

Q I want to connect a Java client program to a C/C++ server application using sockets. What is the easiest way of doing this?

A Java provides the ability to write platform-independent programs that will run on any machine. TCP/IP provides the ability for programs to communicate with each other over a network without regard to their native platforms. Java provides the ability to communicate with other machines via TCP/IP through the java.net package. The Socket class is used to establish TCP connections from a Java program to another program on the network. Communication is treated as a full-duplex stream of bytes from one end to the other. Every byte you write to the stream is read from the other end in the same order that it was written. Likewise, every byte you read from the stream is returned in the same order that it was written by the other end. Use getInputStream() and getOutputStream() to read and write to a socket.

Different hardware platforms represent primitive data types using different byte orderings and bit lengths. For example, current Intel processors store integers in a 32-bit little-endian format while some of the latest SPARC processors use a 64-bit big-endian format. Therefore, in order for different hardware platforms to communicate over a network, they need to agree upon a data representation format. Homogeneous distributed systems may opt to use native representation formats to avoid converting to and from a network byte-ordering. However, the Internet is a heterogeneous system, and the generally accepted format for transmitting integers over the network is in a 32-bit big-endian format. More detailed standards exist, such as XDR (external data representation), which is used primarily to exchange parameters and results via remote procedure calls. The end result is that when you interface a Java client with a non-Java server, you need to understand the data representation convention used by the server and how to convert that to Java data types. The hangups involved in doing this are what make CORBA, XML, and RMI so attractive for building distributed systems. They remove data representation issues from the programmer.

Listing 2 provides a simple client program example that connects to a Time protocol server (IETF RFC 868), reads the protocol-defined data, converts it to a Java data type, and prints out the result.

Q I'm building an application that has several different frames. Each has a button that, when pressed, should bring up a new frame and close the calling frame. How can I display the new frame and close the calling frame?

A Creating a new frame is as simple as following the same steps you followed when creating the original frame. Closing the calling frame requires a little bit of care. You should make sure you create the new frame before closing and disposing of the old frame. One way of doing this is to hide the old frame, create and display the new frame, and then dispose of the old frame. Listing 3 demonstrates how to do this. It creates a frame with an exit button and a button for creating new frames. It registers an ActionListener with the exit button to exit the entire application. The ActionListener it registers with the new frame button takes care of hiding the old frame, creating the new frame, and disposing of the old frame. Keep in mind

Parallel computing is related to distributed computing in that multiple computing resources are used to execute an application. But the focus is quite different

Listing 2 Socket to Me This client program connects to a Time protocol server, reads the protocol-defined data, converts it to a Java data type, and prints out the result. This is one way to connect a Java client program to a C/C++ server application using sockets.

```
import java.io.*;
import java.net.*;
import java.util.*;

public class rdate {
  public static final int TIME_PORT = 37;
  public static final String DEFAULT_TIME_HOST =
    "time.nist.gov";

  /***
   * The number of seconds between 00:00 1 January 1900 and
   * 00:00 1 January 1970. This value can be useful for
   * converting time values to other formats.
   */
  public static final long SECONDS_1900_TO_1970 =
    2208988800L;

  public static void main(String[] args) {
    String timehost = DEFAULT_TIME_HOST;
    long seconds;
    DataInputStream input;
    Socket socket;
    Date date;

    if(args.length > 0)
      timehost = args[0];

    try {
      socket = new Socket(timehost, TIME_PORT);
      input = new DataInputStream(socket.getInputStream());

      // Retrieve the time from the server. The time
      // is the number of seconds since 00:00 (midnight)
      // January 1900 GMT, as specified by RFC 868. This
      // reads the raw 32-bit big-endian unsigned integer
      // from the server and converts it to a Java long.
      seconds = (((long)input.readInt()) & 0xffffffffL);

      input.close();
      date = new Date((seconds -
        SECONDS_1900_TO_1970)*1000L);
      System.out.println(date.toString());
    } catch(IOException e) {
      e.printStackTrace();
      return;
    }
  }
}
```

that an alternative to creating a new frame is to reuse the old frame, simply replacing its contents with a new component panel.

Q How do I determine if a Unix process has stopped writing to a file, so that my Java program can start reading it?

A If you are not able to modify the source code for the Unix program, you may well be out of luck. If you can modify the source code, then you have a few options. The most straightforward is to use interprocess communication to notify the Java program that it is OK to start reading the file. You can do this using a TCP socket, by creating a named pipe that the Java program reads for notification, or just creating a temporary file to signal the go ahead. Another alternative is to use mandatory file locking, if available, and make the Unix process lock the file before writing and unlock it after it is done. This is the best solution because it doesn't require

Listing 3 The Final Frame If you want to display a new frame and close the calling frame simultaneously in your application, you must make sure that you create the new frame before closing and disposing of the old frame. You can do this by hiding the old frame, creating and displaying the new frame, and then disposing of the old frame.

```
import java.awt.*;
import java.awt.event.*;

public class Frames {

  public static class NewFrame extends Frame {
    int _id;
    Button _exitButton, _newFrameButton;

    public NewFrame(int id) {
      _id = id;
      _exitButton     = new Button("Exit");
      _newFrameButton = new Button("New Frame");

      addWindowListener(new WindowAdapter() {
          public void windowClosing(WindowEvent e) {
            Window window = e.getWindow();
            window.setVisible(false);
            window.dispose();
            System.exit(0);
          }
        });

      _exitButton.addActionListener(new ActionListener() {
          public void actionPerformed(ActionEvent e) {
            setVisible(false);
            dispose();
            System.exit(0);
          }
        });

      _newFrameButton.addActionListener(new ActionListener() {
          public void actionPerformed(ActionEvent e) {
            Frame frame;
            setVisible(false);
            frame = new NewFrame(_id + 1);
            frame.pack();
            frame.setVisible(true);
            dispose();
          }
        });

      setLayout(new FlowLayout());
      add(_exitButton);
      add(_newFrameButton);
      setTitle("Frame #" + id);
    }
  }

  public static final void main(String[] args) {
    NewFrame frame;

    frame = new NewFrame(0);
    frame.pack();
    frame.setVisible(true);
  }
}
```

Listing 4 Numbers at Random This program provides a random integer generating class that converts a random double into a random integer within a specific range. It also takes care of reseeding the random number generator after the sequence has been in use for a long time. Use this to write a Java program that generates random numbers with limits.

```
import java.util.*;

public final class RandomIntGenerator {
  public static final int DEFAULT_MIN_RANGE = 1;
  public static final int DEFAULT_MAX_RANGE = 100;

  int _minRange, _maxRange, _range;
  long _numCalls;
  Random _random;

  public RandomIntGenerator() {
    this(DEFAULT_MIN_RANGE, DEFAULT_MAX_RANGE);
  }

  public RandomIntGenerator(int minRange, int maxRange) {
    _random   = new Random(System.currentTimeMillis());
    setRange(minRange, maxRange);
    _numCalls = 0;
  }

  public void setRange(int minRange, int maxRange) {
    _minRange = minRange;
    _maxRange = maxRange;
    _range    = maxRange - minRange + 1;
  }

  public int nextInt() {
    double d;
    d = ((double)_range)*_random.nextDouble();

    if(++_numCalls == Integer.MAX_VALUE) {
      // The pseudo-random number sequence is sufficiently
      // exhausted that it is time to switch to a new seed.
      _numCalls = 0;
      _random.setSeed(System.currentTimeMillis());
    }

    return (_minRange + (int)d);
  }

  public static final void main(String[] args) {
    RandomIntGenerator randomInt;

    randomInt = new RandomIntGenerator();

    for(int i = RandomIntGenerator.DEFAULT_MIN_RANGE;
        i <= RandomIntGenerator.DEFAULT_MAX_RANGE; ++i)
      System.out.println(randomInt.nextInt());
  }
}
```

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any modifications to your Java program. With mandatory locking, the Java program will block if it tries to read the file while it is still locked. If mandatory locking is not available to you, you can also write some native code to enable cooperative file locking from your Java program.

> **If you are only using it for storage, then a Vector will be more efficient than a Hashtable**

Q Is there a significant speed advantage to using Hashtables over Vectors?

A The answer depends on how you are using those classes. If you are only using them for storage, then a Vector will be more efficient. A Vector stores its elements in an array that is resized when its capacity is exceeded. Cycling through elements of a Vector with an Iterator or Enumeration can be very efficient because it only requires indexing into an array. However, if you intend to randomly access the container values based on an arbitrary set of keys, then a Hashtable will be more appropriate, since a Vector does not support that functionality. If you want to use the containers primarily for doing value-based lookups, then neither is appropriate. Searching through an unsorted Vector using indexOf() is O(n), which means that given n elements the method may have to look at every element before finding a value. If you always keep your Vector sorted, you can perform a binary search, which is $O(\log_2 n)$, using Collections.binarySearch(), but will suffer the overhead of repeated calls to Vector's synchronized get() method. Unless you use a value as its own key, a Hashtable will be equally poor. You should also keep in mind that the methods of both Vector and Hashtable are synchronized, which can reduce performance for sequential programs. You should instead try to use ArrayList and HashMap, which you can find in the Java 2 platform. Before you choose a standard Java data structure, consider how you intend to use it. If you are dealing with small amounts of data, almost any one of them will do. For large amounts of data or programs requiring optimal performance, you have to choose carefully or write your own optimized data structures.

Q How do I write a Java program that generates random numbers with limits such as 1–100 or 1–1000?

A The java.util package includes a Random class that will generate a sequence of pseudo-random numbers. Pseudo-random number sequences appear to have a random distribution, but have a definite order. Given the same seed, a pseudo-random number generator will always produce the same sequence of numbers. Therefore, you should initialize the Random class with as random a seed as possible. Using the current time as a seed is often suffi-

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cient. However, when a pseudo-random number sequence is exhausted, it wraps around and starts again from the beginning. Consequently, for long-lived applications that generate many random numbers over time, you will want to periodically reseed your random generator.

The Random class does not provide a generic means of generating random integers within a specific range. Rather, it generates a uniformly distributed set of values between 0 and some upper bound. For doubles and floats, it generates a value between 0 and 1. You can use this to generate arbitrary ranges of random integers. The program shown in Listing 4 provides a random integer generating class that takes care of converting a random double into a random integer within a specific range. It also takes care of reseeding the random number generator after the sequence has been in use for a long time.

Threads are supposed to manage halting on their own; the programmer provides the mechanism

Q How do you stop a Thread without using the deprecated stop() method?

A The recommended way of stopping threads in Java is for each thread to poll a boolean value or condition that indicates whether or not the thread should continue executing. To stop the thread, the boolean value is set to false, causing the thread to exit. In other words, threads are supposed to manage halting on their own; the programmer provides the mechanism. ■

Daniel Savarese is a developer of handheld and wireless applications. He has worked as a senior scientist at the California Institute of Technology and director of Java product development at ORO, Inc. Daniel has written several Java packages, including the OROMatcher and PerlTools regular expression libraries and the NetComponents network protocol library. He is also a co-author of "How to Build a Beowulf." Daniel can be reached at dfs@savarese.org.

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Ask the Java Pro

Parallel Computing with RMI

The growth of the Web and the emergence of real-time interactive services are making parallel programming more important to a wider audience

BY DANIEL F. SAVARESE

Distributed computing is most widely used in business to decentralize services, providing greater transaction processing capacity, and therefore greater scalability. The goal is to be able to service the greatest number of users (client processes) in a reliable manner (fault tolerance). Speed is not optimized so much as is transaction volume.

Remote procedure calls were one of the early attempts to facilitate the development of distributed applications. Later followed distributed object systems such as CORBA, DCOM, and Java's RMI. Plain old client/server systems with XML thrown in for data exchange are now making their presence felt. The systems developed with these different implementation mechanisms remain very similar. They tend to provide a service-oriented application structure that can be leveraged by more than one application. These are loosely coupled, sometimes stateless systems where any number of clients may request a service or set of services for a specific task, such as printing a document or storing a set of records in a database. The nitty gritty details of the service implementation are hidden behind an API that encapsulates the service at a high level. A document may be printed with a single method invocation rather than a lengthy set of application-specific protocol commands. When you request a copy of a document, you don't care if it's being transferred via FTP, NFS, SMB, or HTTP. For that matter, you don't care where the document is located. This is what distributed systems are good at doing. They relieve you from the burden of keeping track of all the resources on the network and how to access each one.

Parallel computing is related to distributed computing in that multiple computing resources are used to execute an application. But the focus is quite different. Parallel computing concerns itself with solving specific problems as fast as possible. Everything from sorting a terabyte of data to simulating galaxy formation falls within the scope of problems tackled by parallel computing. Rather than provide a set of services to distributed clients, the parts of a parallel program work together to reach a particular solution, forming a tightly coupled system. The scaling requirements are such that every time you double the number of processors involved you want to halve the time it takes to solve the problem, or double the size of the problem and solve it in the same amount of time. In practice, linear scaling of this sort is difficult to achieve.

Enterprise application developers usually apply parallel computing techniques to small numbers of processors that share the same memory system. Symmetric multiprocessor (SMP) systems with two to four processors are the most commonly employed. This type of shared-memory programming uses threads to execute a program in parallel. However, SMPs limit your scaling opportunities to the number of processors they contain. Single- or dual-processor servers and workstations are much more abundant on enterprise networks. If you want to solve larger problems and cannot afford the exorbitant cost of a shared-memory supercomputer, you can turn to distributed memory message passing techniques and leverage a readily available cluster of workstations.

At this point you may be asking yourself why you should care about parallel programming? For most of the 90s, it really wasn't relevant outside of scientific computing and specialized business applications. The 90s introduced most programmers to threaded programming, culminating with the wide adoption of Java, a language with built-in thread support; not the first, but the most successful. Programmers also became very familiar with client/server and distributed computing techniques. Now the growth of the Web and the emergence of real-time interactive services are making parallel programming more important to a wider audience.

Let's say you're a dot com that licenses access to the Human Genome Project's data, and charges subscribers for the ability to search the data for specific nucleotide sequences. You could have 60 servers, each of which serves 100 clients at a time, producing the average search result in one minute. Or you could have 60 servers that process searches in parallel, producing the average result in 1–2 seconds and therefore able to handle the same 6000 clients a minute as the previous case, but with much faster response times. Of course, that will depend on the distribution of searches being relatively smooth. Sixty load-balanced servers can handle spikes in traffic much better, but a parallel computing system can deliver faster response

Continued on page 65.

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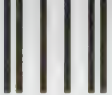

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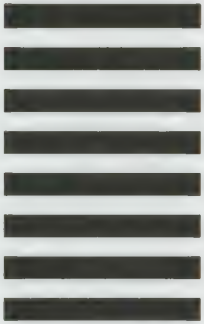

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